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Beginning with this issue a new system of handling reprints goes into effect. Orders for reprints will henceforth be sent to the Business Manager of the JOURNAL, Dr. E. N. Cory, College Park, Maryland, not to the Editor, as formerly was the rule.

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Because of inevitable delays in delivery of the reprints and in the rendering of the bills it may sometimes be well to delay institutional orders, state and federal so that they will be good for the fiscal year in which the reprints will be delivered. This applies particularly to the reprints from the April and June issues of the JOURNAL.

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For the convenience of those who need to know the exact price before an official order can be secured, the new price scale for reprints has been established to include delivery charges in this country. The price scale appended represents, therefore, the total cost of the reprints to the purchaser. This price scale will be found on the inner back cover of the JOURNAL and is printed on the reprint order blanks.

It is hoped that the new system will result in less confusion and greater efficiency in the delivery of reprints.

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Totalitarian Insects

Presidental Address Fifty-Ninth Annual Meeting, American Association of Economic Entomologists

ERNEST N. CORY, *College Park, Maryland*

Social insects are very much like humans. They exemplify in the highest degree the cooperative aggregations that exist from the protozoa to man. Simple groups based on sex, food or protection can be demonstrated with many animal forms. The degree to which they have become socialized partly determines their survival values. Man progressed from family to nomadic tribes. Later more or less permanent abodes developed and these in turn became grouped into associations and later into what we now know as nations. In groups of both man and lower animals, there must of necessity be considerable cooperation. In human society there is also the intense competition for the advancement of the individual not apparent in the social insects. In making comparisons of insects and man, there has been much anthropomorphic speculation. Some has been decidedly fantastic, although sociological, political and economic trends in recent years might appear to have given validity to some of the speculation. Before discussing some of the implications and comparisons with human society, let us refresh our memories on the social organization of bees, ants and termites.

Headed by a functional female known as the queen, the honey bee colony consists of an aggregation of normally non-egg laying females known as workers, and a quantity of drones whose function is to furnish a single consort to fertilize the queen or mother of the colony. After fertilization and until such time as the swarming impulse pervades the colony the queen remains in the place where the colony abode is located. There she begins her life task of laying eggs that develop into workers, drones or queens according to the reflexes of the queen and the activities of the workers. When swarming occurs, the old queen goes forth with the swarm to establish a new colony.

The workers clean the hive and combs, attend to the feeding of the larvae, cap the cells at the proper time and defend the colony for approximately three weeks. They then take their places as field bees, seeking and bringing back nectar and pollen as collective farmers. The nectar is converted to honey in the honey sac and then stored and capped to be used as food for the colony. The pollen is packed in cells to be used as a source of nitrogen, trace elements and vitamins in the food of developing drone and worker larvae. The food of a larva destined to be a queen is known as royal jelly developed from the salivary glands of the worker bees. Thus a new queen is developed from a selected larva in a special cell, on a special diet.

This brief summary of the colony organization of the honey bee will serve as a background for a consideration of other social insects. There is no need to burden you with details that you know as entomologists, but certain specializations that are departures from the division of labor exemplified by the honey bee will be pointed out.

The ant colony has essentially the same organization, a matriarchy, although for short periods males are produced, mate and die leaving the working colony one of females. The specializations are numerous and interesting especially from the standpoint of food acquisition. As pointed out by Kennedy, both bees and ants live by the labor of adults. Civilized man likewise strives to live by adult labor. The immature stages, devoid of means of obtaining food and with restricted locomotion, are fed, bedded and protected by adults. Some adults are cultivators of

fungous gardens, others are harvesters of grass seed, some are slaves, some protect and transport aphids to make available their sweet excretions as food. Sufficient food is utilized by adult workers to maintain an intense round of field activities but apparently the major concern is to provide elaborated food for the helpless young and the queens of mothers of the colony.

The termite organization departs in important aspects from that of bees and ants. Its very seclusion dictates a more rigid economy. The working colony is not exclusively female as males in the several castes are approximately equal in numbers to females although they have no role in colony increase, a function left to a select few.

In the spring and sometimes at other periods during the year, a colony produces a large number of winged males and females which go forth on nuptial flights. These winged individuals pair and mate then seek a suitable place in the soil in which to establish a new colony. They tear off their wings and thereafter remain for the rest of their lives in the soil chamber. The queen or mother begins to produce eggs about four to six weeks after mating. The eggs are laid singly and from six to twelve constitute the first batch. The eggs hatch into workers which care for the newly deposited eggs and the young that issue thereform. The queen provides food from her reserves for the first young to hatch but later simply becomes an egg laying machine. As the colony develops, other castes are formed; particularly two types of soldiers which guard the colony, workers, accessory reproductives and the periodically swarming winged male and female reproductives.

The workers feed on wood. The cellulose is digested by enzymes produced by protozoa that live within the intestinal tract of the termites. Without these protozoa the individual dies and a defaunated colony would shortly become extinct. The protozoa are transferred in stomodeal and proctodeal excretions.

In each of these colonial groups there is a high degree of specialization in food collection and elaboration, feeding the inmates, shelter construction, protection of the colony, reproduction and colony increase and limitations. From the very beginning (even in the determination of the destiny of the egg) a completely controlled economy is in evidence. Thus they exemplify in the highest degree the human ideology of the totalitarian state, with this important difference; in insect societies leadership is based on functional, biologic competence; in human society leadership is frequently fortuitous and simply administrative.

Because bees, ants and termites are motivated by similar impulses to create totalitarian colonies does it follow that they can live in peace and harmony? No, just as in human society self interest prevails. The ant is deemed the principal enemy of the termite; the bee sometimes vies with the ant for the honey dew from the same source and fills its combs with melezitose.

Food elaboration and the feeding of the colony in bees and ants is the function of the adult that is not yet ready for the field. In termites this is entrusted to immature inmates. Construction, maintenance and repair of housing structures is a specialized duty of designated groups within the colony. Soldier castes are created in the termite colony to fight against its enemies; hive bees and ants designate for protection of the colony certain individuals until they have matured and others have been produced to take their places. They then fare forth as foragers.

Reproduction is the most highly specialized function of the colony and includes the ideas of population increase and limitation as well as the production of specialized castes for particular purposes. There is no need to particularize in regard to these castes but it is desirable to impress upon you the idea that colonial forms we are considering have the power to predetermine through fertilization or non-fertilization or by subsequent larval food the caste of each and every individual that is to be a component of any one of these totalitarian colonies. When the colony is small the emphasis is upon increase. When the proper limits are reached, a swarming impulse results in an exodus from the colony. This swarm serves to create a new colony, reduce the congestion within the parent nest and provide for wider dispersion of the species and greater probability of survival. From the beginning, the duties, number and sex of each individual are determined with relation to the colony needs. Each individual serves the colony and in turn the colony

serves the individual in matters of food, shelter and protection from the natural enemies, exclusive of man. Herein is the true socialistic state successful through the ages presumably because these insects are biologically equipped to produce the kind of castes needed, a population optimum and are motivated by colony consciousness which assures maximum survival values for the masses. Selfishness is absent and individual development or evolution is not apparent.

Man has approached the success of colonial insects in some of his material needs. In the production, processing, storage and preparation of food, human society has made considerable progress. In distribution in the larger sense attempts to control supply through price regulation, incentive payments, or other artificial means have failed through the ages. Artificial control of prices and supply failed as early as 1700 B.C. during the 17th dynasty in Egypt. This failure to control food has been repeated notably in China, Athens, Rome, Britain, Belgium, India, France and in the United States both in colonial and recent times. Why? Because of human greed; an attribute apparently missing from social insects. They supply food to every member of the colony at the price of unremitting labor.

In shelter man has surpassed the insects except that in the air conditioning of abodes, the termites, ants and bees have had competent engineering for a longer time than has man.

The control of population has intrigued man and governments mostly through fear that the numbers would exceed the supply of food or the ability of the individual to secure an adequate supply. The decline of populations has also engaged the attention of man and many attempts have been made to correct the trend through health organization, bonus payments to mothers and by legalization of births out of wedlock. How much simpler the scheme of the colonial insect which has mastered the control of sex, caste, and population, and has thereby fitted population to supply.

If human society could attain the selflessness of the social insects, the material needs of nations probably could be achieved without serious difficulties. These groups might live in propinquity and peace. This would be a mode of living that might have its merits but which is strictly limited by human selfishness from which there seems to be no escape in the foreseeable future. How would you like to have the destiny of an ant, bee or termite? Would you want to work at appointed tasks indefinitely with no chance ever to improve, to change your job, or even to achieve something better materially? Would you trade your individuality for nonentity; your initiative for security? If you have no faith in your ultimate destiny, then let the planners arrange a termite like totalitarian existence for you.

Man is not biologically equipped to control sex, caste or population. If he were so equipped he might develop a society in which his minimum material needs could be achieved more readily. However, he has a higher destiny, the right to his individual evolution, which is denied to the member of a totalitarian society be it human or insect and is accorded to every individual in a democratic human society. Herein lies the essential difference between the totalitarian and democratic philosophies. The difference should be especially apparent to entomologists, but it is frequently obscured under an ideology that has as its central theme certain socialistic theories in regard to labor, wealth and the state. Thus the creation of scientific materialism overshadows the development of the individual just as it does in the totalitarian insect colony.

Man is confronted not only with material but moral and spiritual needs. The dignity of the individual is of paramount importance. By our action and expressed thought it is evident that Americans believe each individual has a right to evolve in moral and spiritual values. In order to protect the individual and provide the opportunity to acquire moral and spiritual values, our government guarantees us certain "inalienable rights" in the Bill of Rights. These have little direct relation to socialistic or capitalistic theories, both of which deal with materialism but bear a direct relation to our opportunities for spiritual development.

The war we have recently concluded developed largely from a conflict of philosophies of society. On one side was the concept of the individual right to develop materially, morally and spiritually along competitive lines with freedom to act in any way so long as the actions do not

contravene the rights of others. On the other side, the philosophy was diametrically opposite to that concept. It envisioned a regimented society like the totalitarian insects, biologically equipped for regimentation, in which individual development is of no moment except insofar as it contributes to the material welfare of the society. In the one, the society assures the individual protection in the pursuit of his destiny and in the other denies to the individual any destiny other than that of a cog in a gigantic machine to produce wealth to be apportioned in the form of food, shelter and protection in such amounts and manner as the totalitarian machine may dictate.

As entomologists familiar with the economy of bees, ants and termites we should be in a better position than most individuals to analyze the doubtful benefits and manifold disadvantages of a totalitarian society under whatever name it masquerades and to publicize the essential difference between totalitarian and democratic philosophies. We must point out the serious consequences in the complete loss of individual development under any totalitarian scheme. Furthermore we should attempt to clarify our thinking, now beclouded by issues of socialism, capitalism and labor and make it plain that the real issue lies in the determination of whether moral and spiritual values will prevail over scientific materialism.—December 28, 1947, Chicago, Illinois.

Time of Planting Potatoes as a Factor in Prevention of Potato Psyllid Attack

R. L. WALLIS, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The early crop of potatoes grown in western Nebraska and eastern Wyoming amounts to less than 10 per cent of the total acreage planted to potatoes in this area. It has long been known that this early crop is subject to more severe attack by insects, especially the potato psyllid, *Paratrioza cockerelli* (Sulc), than are later plantings. The data discussed here were taken in this area from 1939 to 1946 and show the average populations of potato psyllids on early and late plantings of potatoes.

A review of the literature indicates that little attention has been paid to psyllid infestations in relation to planting time. Hartman (1937) found in Wyoming in 1935 that potato fields planted before the first of June showed larger numbers of psyllid nymphs and more psyllid yellows symptoms than did fields planted later. While psyllids in later plantings could be found in some fields, there was comparatively little damage from psyllid yellows. As a result of the greater damage in the early planted fields in 1935, most of the 1936 crop of certified seed potatoes was not planted until after the middle of June. Eyer (1939) states that the late-planted potatoes and tomatoes do not develop psyllid yellows as severely in southern New Mexico as those planted earlier, because of high temperatures occurring during the period of growth of the later plantings. In the northern half of the state and in the mountain areas where temperatures are not so high, symptoms of psyllid yellows are severe regardless of time of planting.

METHODS.—The potatoes used in this study were all of the Bliss Trimph variety. Observation points in commercial fields were established at random over the North Platte Valley in western Nebraska and eastern Wyoming, and population counts were made at each point at 5 to 7-day intervals. Population counts were made by the sweep-net method. From one to four 100-sweep samples were taken at each observation point. The sweep-net was brushed briskly across the tops of the plants, the tops being allowed to cover approximately half the net opening. On the early crop of potatoes, planted in April, sampling was begun June 1 and continued until harvest, about August 1. The commercial late crop of potatoes, planted from about May 25 to July 1, was divided into two crops designated as medium and late crops, for the purpose of determining the difference in psyllid infestation. Fields selected as a medium

crop were planted from May 25 to June 10. Observations were started on this crop on July 1 and continued until harvest, about September 30. The fields selected in the late crop were planted from June 20 to 30. Observations were started on July 15 and continued until harvest, about September 30.

RESULTS.—Over a period of eight seasons adult psyllid populations averaged considerably higher on early planted potatoes than on either the medium or late crops, as shown in table 1. Populations on the medium crop averaged 37 per cent and populations in the late crop 28 per cent of those on the early crop. The difference between the numbers on the medium and late crop was not so great, the population on the late crop being 75 per cent as high as on the medium crop. Greater variation occurred from one season to another on the early planting than on either of the later plantings. This was apparently due to the great variation in the size of the spring peak of population, which occurs near the end of June, when the plants of the early crop are large. Wallis (1946) has shown that this spring peak of population, which is apparently an influx from overwintering sources, varies considerably from one season to another, and that high temperatures in midsummer will reduce populations on small plants, but not on large plants. The early crop reaches its maximum growth early in July, and populations continue to increase until harvest. The lighter infestations on the later plantings are apparently due to the plant growth after the spring peak and to high temperatures in July which retard psyllid breeding when the plants are small. Although the acreage of early potatoes in this area is small, this early crop is the only host on which psyllid populations continues to increase during the critically high temperatures of July. Therefore it serves as host plant through the critical period to the more important late crop.

CONCLUSIONS—From these data it may be concluded that the best time to plant potatoes in the western Nebraska and eastern Wyoming area to avoid high psyllid infestations is after June 15. Particular attention to the control of psyllids on the early crop, or the elimination of the crop in areas where practical, would aid in preventing attacks on later plantings.

Table 1.—Average yearly populations of adult potato psyllid on early, medium, and late plantings of potatoes. [Numbers per 100 sweeps.]

YEAR	EARLY CROP	MEDIUM CROP	LATE CROP
1939	16.7	1.8	1.6
1940	1.3	1.1	.5
1941	5.8	1.9	2.6
1942	3.8	2.8	1.1
1943	.5	.1	.1
1944	3.0	3.0	2.9
1945	1.1	—	.1
1946	2.6	.7	.3
Mean	4.3	1.6	1.2

SUMMARY.—A survey of adult potato psyllid populations on early, medium, and late plantings of potatoes from 1939 to 1946 in the North Platte Valley of Wyoming and Nebraska showed that potatoes planted in April are more subject to attack by this insect than potatoes planted after June 1. Only 37 per cent as many psyllids were found on the medium crop as on the early crop, and 28 per cent as many on the late crop as on the early crop. The higher populations on the early planting is apparently due to its growth during late June, when an influx of psyllids from overwintering sources occurs, and to the fact that the plants reach their maximum growth in July, when critically high temperatures occur. These high temperatures retard the development of psyllid populations on the small plants of later plantings.

Particular attention to the control of psyllids on early potatoes is necessary to produce a good crop and to prevent the carrying over of large numbers of psyllids that will be injurious to later plantings.

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Plants Upon Which Tuber Flea Beetles and Western Potato Flea Beetles Propagate

B. J. LANDIS, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1,2]

The tuber flea beetle, *Epitrix tuberis* Gentner, and the western potato flea beetle, *E. subcrinita* (Lec.), feed on a wide variety of crops and weeds in the Yakima Valley, Washington, but are most destructive to potatoes. Populations of the tuber flea beetle, especially, must be kept at a very low level on potatoes, if larval damage to the tubers is to be prevented. In order to determine the relative importance of various plants for the propagation of these two potato flea beetles, certain plants fed upon by the adults in the field were caged with larvae in the laboratory at Yakima, or the newly emerged adults were collected in traps placed over naturally infested plants in the field.

The reproduction of the tuber flea beetle and the western potato flea beetle has been observed principally on solanaceous plants (Hill 1946; Landis 1943). Hill found that in cage tests the tuber flea beetle reproduced on various solanaceous plants and on beans, but that the greatest numbers were produced on potato. Hill also observed that, in Nebraska, populations of this beetle were largest in areas where both early and late potatoes were grown, and he concluded that if the early-potato crop in the late-potato district were discontinued the general populations level would be lowered because of forced feeding and reproduction on less productive hosts. Hill & Tate (1944) recommended that potatoes be planted as late in the season as practicable and that timely application of insecticides be made for control of the tuber flea beetle.

Until a few years ago most of the potatoes grown at Yakima were for a late crop, but competition with other producing areas has caused many growers to plant for an early crop. The transition from late to early planting has brought about no noticeable increase in the general populations of the tuber flea beetle and the western potato flea beetle. An early crop may be harvested during the first week of July, and although emergence of the overwintering tuber flea beetle reaches a peak about June 15, little damage may be done to tubers by larvae if harvest is not delayed.

The local practice of planting potatoes at intervals from March 15 until July 10 provides a succession of hosts on which reproduction of the two species of potato flea beetles may occur for approximately 170 days. The early-potato crop appears to serve as a means of concentrating the tuber flea beetles as they emerge from hibernation, and the periodic application of insecticides greatly reduces the numbers of overwintering beetles and prevents the development of large numbers of first-brood adults, which may injure later plantings.

The timely application of insecticides has made the potato much less suitable as a propagating host of these flea beetles than formerly, and although little or no sorting out of infested tubers may be necessary at Yakima to meet U. S. grade tolerances, still a trace of infestation too little to be classified as damage is objectionable on a highly competitive market. In further attempts by growers to improve the quality of the crop, the unrestricted development of these flea beetles on less productive host plants becomes increasingly important.

FEEDING HOSTS.—Swenk & Tate (1940) observed some correlation between numbers of the tuber flea beetle in potato fields and the abundance of wild and cultivated vegetation in adjoining and nearby areas, and they considered it advisable to prevent the growth of vegetation that might serve as alternate hosts.

Many different plants, most of which probably do not serve as propagating hosts, are fed upon by the adult beetles. Essing (1938) records potato flea beetles common to the West as feeding on the following plants: Apple, arbutus, ash, bean, beet, bird cherry, cabbage, carrot, celery, clover, corn, cucumber, dogbane, eggplant, elder, groundcherry, holly, honeysuckle, hop, horsechestnut, horsenettle, jimsonweed, lettuce, maple, musk-

[1] In cooperation with the Washington Agricultural Experiment Station.

[2] The author is indebted to R. S. Wright and P. J. Jenkins for assistance with the rearing work.

melon, nightshade, pepper, petunia, phlox, plantain, primrose, pumpkin, radish, raspberry, rhubarb, St. Johnswort, sarsaparilla, sorrel, spinach, sumach, sunflower, sweetpotato, tobacco, tomato, turnip, viburnum, violet, watermelon, and wonderberry.

Additional feeding hosts recorded by several observers are golden husk tomato and rush (Hanson 1933); cos and squash (Hoerner & Gillette 1928); groundcherry, *Physalis* sp., and buffalo-bur, *Solanum rostratum* Dunal, (Swenk & Tate 1940); and marsh-elder, *Iva xanthifolia* Nutt., kochia, *Kochia scoparia* (L.), and wild tomato, *Solanum triflorum*, Nutt., (Hill 1946).

At Yakima potato flea beetles have also been obesrved feeding on bindweed, *Convolvulus arvensis* L., smaller bur-marigold, *Bidens cernua* L., dandelion, *Taraxacum officinale* Weber, broad-leaved dock, *Rumex obtusifolius* L., common plantain, *Plantago major* L., and buckhorn plantain, *P. lanceolata* L.

At Yakima, flash infestations of the tuber flea beetle, emerging from overwintering quarters during May and June, appear on various weeds, and may injure potatoes and many seedling crops. The beetles disperse rapidly from most of these plants but on others varying numbers remain and some reproduction occurs throughout the season. Early-season damage by the western potato flea beetle is less common, because the adults become active and disperse very early in the spring, before the most susceptible crops, except potatoes, are present. Even on early potatoes foliage injury is greatest during the first 2 weeks of plant growth, after which many beetles leave this crop for other host plants.

OBSERVED PROPAGATING HOSTS.—Several workers have recorded finding different species of potato flea beetles reproducing on various plants in the West, but none except Hill (1946) state clearly that the flea beetles were reared to the adult form and identified as to species. Until 1944 the most destructive of the flea beetles attacking potatoes in the West was referred to as the potato flea beetle, *Epitrix cucumeris* Harr., found abundantly in the East. Gentner (1944) has described this common tuber-infesting flea beetle as *E. tuberis*, and although most records of *E. cucumeris* in areas from Nebraska westward probably refer to *E. tuberis*, both may occur in some localities. Published records referring to potato flea beetles without differentiation as to species also may include other flea beetles, especially the western potato flea beetle, *E. subcrinita*.

Hill (1946) bred *Epitrix tuberis* on potato, *Solanum tuberosum* L., tomato, *Lycopersicon esculentum* Mill., field bean, *Phaseolus vulgaris* L., a groundcherry, *Physalis lanceolata* Michx., buffalo-bur, *Solanum rostratum* Dunal, and black nightshade *s. nigrun* L. Hanson (1933) reported that larvae or pupae of flea beetles, *E. tuberis* and *E. subcrinita* or both were found beneath eggplant, *S. melongena* L, golden husk tomato, *P. pubescens* L., and Chinese lantern plant *P. francheti* Masters. Daniels (1933) reported finding larvae and pupae of flea beetles, which he assumed to be *E. cucumeris* but Gentner (1944) believes to have been *E. tuberis*, beneath plants of purple groundcherry

Table 1.—Plants tested as food for larvae of the tuber and western potato flea beetles in the laboratory at Yakima, 1941–42.

	Plant Parts Used	Larvae Tested	Adults Produced	Hatching to Adult
		Number	*Number*	*Days*
	Tests with Epitrix tuberis			
Arctium lappa L.	Roots	50	0	—
Capsicum fruitescens L.	Roots	20	0[1]	—
	Seedlings	15	0	—
	Green fruit	25	0[1]	—
Chenopodium album L.	Roots	50	0[1]	—
Datura meteloides DeC.	Roots	15	1	34
Hibiscus esculentus L.	Roots	40	0[1]	—
Lycopersicon esculentum Mill.	Roots	25	0	—
	Seedlings	15	0	—
	Green fruit	25	5	39
	Ripe fruit	25	0[1]	—
Physalis francheti Masters	Roots	25	0	—
Plantago lanceolata L.	Roots	50	0[1]	—
Solanum dulcamara L.	Roots	50	5	45
S. melongena L.	Roots	25	0	—
	Seedlings	15	1	36
	Fruit	25	2	70
S. nigrum L.	Roots	50	1	35
S. villosum (L.) Mill.	Roots	65	16	42
S. triflorum Nutt.	Roots	25	0[1]	—
S. tuberosum L.	Roots	100	5	35
	Tubers	60	24	29
	Aerial stems	100	3	34
	Seed balls	25	0	—
Urtica dioica var. *procera* (Muhl) Wedd.	Roots	50	0[1]	—
	Tests with Epitrix subcrinita			
Capsicum frutescens L.	Roots	25	1	65
Chenopodium album L.	Roots	25	0[1]	—
Cucurbita pepo L.	Roots	50	1	66
Plantago lanceolata L.	Roots	25	0[1]	—
Solanum dulcamara L.	Roots	50	4	83
S. nigrum L.	Roots	25	0	—
S. villosum (L.) Mill.	Roots	25	4	85
S. tuberosum L.	Roots	100	6	36
Urtica dioica procera (Muhl.) Wedd.	Roots	25	0[1]	—

[1] No feeding.

Quincula lobata (Torr.) Landis (1943) observed some reproduction of potato flea beetles on pumpkin *Cucurbita pepo* L., pepper *Capsicum frutescens* L., and black nightshade *Solanum villosum* (L.)

During 1941 and 1942 a number of plants and plant parts were tested as possible larval hosts of the tuber and western potato flea beetles in the laboratory at Yakima. The newly hatched larvae were placed in the soil of potted plants, or confined with selected plant parts in tin or glass containers. The food materials were changed periodically and soil was added prior to pupation of the larvae. Frequent examinations of the cultures caused a high mortality of the larvae, but it was apparent that larval development was possible on a great number of plants and was not restricted to the *Solanaceae* (Table 1).

Table 2.—Emergence of flea beetles from soil of naturally infested plants during periods of observation.

Host Plant	Plants in Test	Average Period of Test	Flea Beetles Produced Per Plant	
			E. tuberis	*E. subcrinita*
	Number	*Days*	*Number*	*Number*
Capsicum frutescens	3	72	0	1.3
Datura meteloides	4	70	4.3	17.0
Datura stramonium L.	4	68	5.8	47.0
Nicandra physalodes (L.) Pers.	3	70	5.7	7.3
Nicotiana alata var. *N. grandiflora* Comes	2	69	83.5	342.0
Phaseolus vulgaris L.	3	57	3.7	1.7
Physalis francheti Masters	3	72	3.0	18.0
P. longifolia Nutt	10	62	45.4	22.6
P. pubescens L.	5	57	2.0	15.8
Solanum carolinense L.	4	70	2.0	20.0
S. dulcamara	2	75	7.0	114.0
S. nigrum	6	54	1.0	16.7
S. villosum	5	64	0.6	10.2
S. rostratum Dunal	4	69	14.3	37.0

During 1942 a wide variety of plants were grown in the laboratory garden, where they were exposed to the natural infestation of potato flea beetles. During July and August several plants of each species found to have been fed upon were cleared of beetles, the foliage was cut off at ground level, and insect-emergence traps were placed on the soil. The traps were examined for 54 to 75 days. The newly emerged flea beetles were taken from the traps, counted, and identified as to species. In general, the plants found satisfactory for larval development in the laboratory also were found to be infested in the garden (Table 2).

RELATIVE IMPORTANCE OF ALTERNATE PROPAGATING HOSTS AT YAKIMA.—Table 2 shows that considerable reproduction of both species of potato flea beetles occurs on certain host plants other than potato. The economic importance of these alternate propagating hosts, therefore, depends largely on their abundance within the potato-growing areas. The relative importance of these hosts at Yakima is discussed in the following paragraphs.

Tomatoes.—Approximately 750 acres of tomatoes and 10,000 acres of potatoes are grown annually at Yakima. Tomato plants grown from field-sown seed are attacked by overwintering flea beetles, especially the tuber flea beetle, during May and June, and an insecticide may be applied if the foliage is severely damaged. Larger quantities of irrigation water are required for tomatoes than for potatoes, and heavy watering appears to favor the production of larger numbers of the tuber flea beetle.

Although Hill (1946) has shown that fewer tuber flea beetles may be produced on tomatoes than on potatoes, the lack of a systematic seasonal insecticide program on tomatoes at Yakima makes this crop the principal source of tuber flea beetle infestation for potatoes. During the second week in August 1941, newly emerged tuber flea beetles were observed in large numbers along the edge of a potato field bordering a tomato field. The soil about two tomato plants was examined, and 110 large larvae and pupae were collected, from which 28 tuber and 2 western flea beetles were reared to the adult stage.

Growers producing both tomatoes and potatoes in the same season have found flea beetles, especially the tuber flea beetle, extremely difficult to control on potatoes during the same season and also the following year. In many cases it has been more hazardous to plant potatoes in old tomato fields than in potato ground, presumably because of the larger tuber flea beetle populations that were allowed to develop during the preceding year.

Miscellaneous Cultivated Solanaceae.—Small plantings of eggplant are made on truck farms throughout the potato-growing area. Plants started under glass may be severely damaged by flea beetles, especially the tuber flea beetle, either prior to or shortly after being transplanted to the field. In the second week of August

1941, a part of the soil about 6 plants in a small planting was examined, and 122 larvae and pupae were collected. Fifty-four tuber and 12 western potato flea beetles were reared to adult form.

Although sweet peppers are grown in some quantity, there is little reproduction of either flea beetle on these plants. *Nicotiana alata* var. *grandiflora*, *Nicandra physalodes*, *Physalis pubescens*, *P. francheti*, and *Datura meteloides* are found in gardens, but are of little economic importance as propagating hosts of flea beetles because of their limited occurrence. *Solanum dulcamara*, however, has spread from gardens and grows along irrigation ditches and streams in considerable quantity. The foliage is attractive to potato flea beetles, especially the tuber flea beetle, and the perennial habit of the plant is favorable for the continuous reproduction of the beetles in out-of-the-way places year after year.

Nonsolanaceous Crops.—Various cucurbits and snap beans are grown in some quantity at Yakima, and although reproduction of both species of potato flea beetles appears to be slight on these plants, they are, nevertheless, potential propagating hosts. Small Marblehead squash plants growing in an old tomato field during the spring of 1942 were observed to be badly damaged by adult tuber flea beetles. Small numbers of both species may be found on melons, squash, pumpkin, and beans throughout the season.

Solanaceous Weeds.—Black nightshade, *Solanum villosum*, grows abundantly in the cultivated fields of the Yakima Valley, as well as along streams and in the foothills. Many of these plants occur in crowns of potato rows, where they escape the usual cultivation. Large numbers of plants also occur in fallow ground and in solid crops such as alfalfa, grain, and peas.

Nightshade seedlings appear in field headlands or in seepage areas very early in the spring, and this plant is one of the first to be fed upon by the western potato flea beetle. Later both species feed and reproduce on this plant, but in much smaller numbers than on potato. Because of its wide distribution and its abundance, the nightshade plant is believed to be responsible for the maintenance of potentially injurious populations of these flea beetles in areas where long-term rotations of unsatisfactory host crops with potatoes or tomatoes should otherwise cause the wide dispersal of the beetles.

Physalis longifolia, a deep-rooted perennial weed, has become established in many fields and is a satisfactory propagating host for both species of potato flea beetles. At present the distribution of this weed is restricted to relatively small areas.

Buffalo-bur, horsenettle, *Solanum carolinense*, and jimsonweed, *Datura stramonium*, are rarely found at Yakima. Wild tomato, *S. triflorum*, occurs on light soils and in the foothills, and although it is a feeding host for adult potato flea beetles, especially the western potato flea beetle, no reproduction was observed on this plant.

SUMMARY.—Reproduction of the tuber flea beetle, *Epitrix tuberis* Gentner, and the western potato flea beetle, *E. subcrinita* (Lec.), was found to occur in the Yakima Valley, Washington, on a large number of cultivated plants and weeds. Flowering tobacco, a ground cherry, and buffalo-bur, are suitable propagating hosts, but are of little economic importance because of their scarcity. Tomato, European bittersweet, and black nightshade are somewhat less suitable than potato as propagating hosts, but occur in large numbers and appear to be a considerable source of production of both species of potato flea beetles for possible infestation of potatoes.

Early potatoes grown at Yakima serve as a trap crop for tuber flea beetles emerging from hibernation, and timely applications of insecticides to this crop prevent the development of large numbers of first-brood beetles, which might otherwise be difficult to control on late plantings of potatoes.—12-1-47.

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A Potato Resistant to Tuber Infestation by Flea Beetle Larvae

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In tests made by the Western Washington Experiment Station at Puyallup, Wash., in 1945 on different varieties of potatoes, it was noted that tubers of the Doe Bay Red variety were only slightly injured by flea beetle larvae. An experiment was therefore conducted at Union Gap, Wash., in 1946 by the Bureau of Entomology and Plant Quarantine, in cooperation with the Washington Agricultural Experiment Station, to determine the relative susceptibility of Doe Bay Red and certain other varieties to injury by larvae of the tuber flea beetle, *Epitrix tuberis* Gentner.

Because of the tuber-infesting habit of its larvae, the tuber flea beetle is the most destructive flea beetle that attacks potatoes. In parts of the West, where it is the most abundant flea beetle on potatoes, the adult populations may be too low to cause appreciable injury to foliage, and yet the larvae may severely damage the tubers. Potato tubers are not essential for development of the larvae, and in some infestations little correlation may be shown between the total larval population within a hill of potatoes and the number of larvae in the tubers. In such cases, the resistance of some varieties of potatoes to foliage injury, although desirable, is of much less economic importance than the resistance of tubers to larval infestation.

Certain varieties of potatoes that have been developed within the last few years have been reported to have foliage resistant to flea beetle attack. These reports were based on observations made in the East and probably refer to the potato flea beetle, *Epitrix cucumeris* (Harr.), the larvae of which rarely infest potato tubers. Stevenson (1940) reported that the Chippewa, Sebago, and Sequoia varieties were only lightly infested with flea beetles, and that the Mesaba and Pontiac varieties were only moderately infested. Later, Stevenson (1945) reported that Mohawk was moderately resistant to flea beetles, and Jehle & Stevenson (1945) found Potomac to be more resistant than Sebago, but less so than Sequoia. Hardenburg & Stevenson (1943) found that, of 16 varieties of potato observed, the Mohawk showed less injury from flea beetles than any other varieties except Sequoia and Houma. No reference to possible varietal resistance of potato tubers to flea beetle larvae was found. However, if the foliage resistance reported by various workers is of a repellent nature, then oviposition and larval development of flea beetles in the soil of such potato hills may be less than that in hills of the more susceptible varieties, and fewer larvae would be present to infest the tubers.

During a search for varieties or strains of potato showing field resistance to potato troubles, a variety from the San Juan Islands was found to be unusually thrifty and disease-free. It is known locally as the Doe Bay Red and was imported from Denmark to Whidbey Island, in Puget Sound, many years ago. About 1922 it was brought to Orcas Island, San Juan, and became a popular garden variety because of its good keeping qualities. Captain Bruce Willits, who has resided in the San Juan Islands for

25 years, states that this potato was once called the Scarlet Rose. In most characters it fits the description of the Rose group, as described by Stuart (1915).

RESISTANCE TO DISEASE.—Slightly resistant to late blight, *Phytophthora infestans* Du Barry, on foliage; tuber resistance not known. Two years of field tests of tuber samples taken from locally grown stock showed no leaf roll in the original sample and no leaf roll pick-up during this period.

RESISTANCE TO POTATO FLEA BEETLES.—Preliminary tests with the Doe Bay Red variety at the Puyallup, Wash., station indicated that the tubers were only slightly infested with flea beetle larvae. This variety was, therefore, compared during 1946 at Union Gap, Wash., with several commercial varieties to determine the relative susceptibility of the tubers to this type of injury. The seed pieces were planted April 1 in a field that had been heavily infested with the tuber flea beetle, *Epitrix tuberis*, and the western potato flea beetle, *E. subcrinita* (Lec.), for a number of years.

The varieties Doe Bay Red, Chippewa, White Rose, Netted Gem, and Burbank were compared. Each plot contained one hill, and the hills were planted 2 feet apart and arranged in 17 randomized-block replicates. Adult potato flea beetles were numerous on the plants throughout the growing season and all varieties showed some foliage injury. The foliage of the Doe Bay Red plants remained green longer than that of the other varieties, probably because of slower growth and relative freedom from disease. No insecticides were applied.

On July 10, 100 days after planting, all plants in nine replicates were cut off at ground level and insect traps were placed over each bare hill to collect the new-brood beetles emerging from the soil. The beetles that emerged in the traps during a 40-day period were counted as to species.

More adults of the tuber flea beetle were collected from hills of Doe Bay Red than from those of any other variety (Table 1). This fact indicates that the plants were not repellent to the ovipositing females and that larvae were able to develop satisfactorily under them. Relatively few adults of the western potato flea beetle were collected and more were obtained from the hills of White Rose than from those of Doe Bay Red.

Table 1.—Number of adult flea beetles that emerged from hills of different varieties of potatoes during a 40-day collection period preceding harvest.

POTATO VARIETY	*Epitrix Tuberis*	*E. Subcrinita*
Netted Gem	887	90
Chippewa	1,132	91
Burbank	1,184	103
White Rose	1,209	125
Doe Bay Red	1,629	71
Difference required for significance (odds 19:1)	299	45

In the 8 replicates in which the potatoes were allowed to develop to maturity the tubers were harvested on August 12. Five of the largest tubers from each hill, 40 for each variety, were peeled and a count was made of the number of tunnels made by larvae of the tuber flea beetle. The tubers of the nine replicates in which the tops of the plants had been removed on July 10 were harvested on August 23, and all of them were peeled and examined for tunnels.

Although more adults of the tuber flea beetle emerged from the hills of Doe Bay Red potatoes than from any other variety, the injury by the larvae to the tubers of this variety was less than on those of any other (Table 2). When the numbers of tunnels per tuber are compared, the difference in injury is seen to be more outstanding than in comparison with the numbers of tunnels per gram of tuber.

Table 2.—Yield of different varieties of potatoes and number of tunnels made in the tubers by tuber flea beetle larvae.

CULTURAL TREATMENT AND VARIETY	TOTAL YIELD OF TUBERS: TUBERS POUNDS	TOTAL YIELD OF TUBERS: TUBERS EXAMINED	LARVAL TUNNELS: Per tuber	LARVAL TUNNELS: Per gram of tuber
Plants allowed to mature:				
Netted Gem	22	40	84	0.43
Chippewa	23	40	61	.36
Burbank	12	40	66	.90
White Rose	22	40	62	.38
Doe Bay Red	15	40	20	.14
Difference required for significance (odds 19:1)	8	—	22	.24
Foliage removed July 10:				
Netted Gem	10	71	39	.65
Chippewa	10	55	41	.50
Burbank	10	80	59	.97
White Rose	11	53	42	.41
Doe Bay Red	6	48	16	.30
Difference required for significance (odds 19:1)	4	24	22	.29

This fact is probably due to the smaller size of the Doe Bay Red tubers.

The injury to tubers of uniform size was also recorded separately. Doe Bay Red tubers, weighing from 100 to 150 grams, had an average of 28 larval tunnels per tuber, whereas comparable tubers of the other four varieties had an average of 54 tunnels per tuber. These data indicate that the difference in injury by flea beetle larvae cannot be attributed to tuber size.

It appears that, although the tubers of the Doe Bay Red were less severely injured by larvae of the tuber flea beetle than were those of other varieties, the plants of this variety are fully as favorable for the development of the larvae. No positive suggestions can be made at this time regarding the varietal characteristics that may contribute to the apparent resistance to injury. It may be significant however, that the fibrous root system of Doe Bay Red is noticeably greater than those of other varieties tested.

The foliage of Chippewa was reported to be somewhat resistant to potato flea beetles in West Virginia (Stevenson 1940) and the present authors also observed it to be more resistant to foliage injury than were the other varieties. However, the larval infestation in Chippewa tubers was significantly greater than in tubers of the foliage-susceptible Doe Bay Red.

In a fertilizer test at Union Gap, Wash., data were obtained on injury by larvae of the tuber flea beetle to tubers of Netted Gem, Burbank, Chippewa, and Doe Bay Red varieties. The seed pieces were planted on May 15 in a single 120-foot row for each variety. No insecticides were applied. The tubers were harvested on September 24. Doe Bay Red yielded only 52 per cent as many marketable-sized tubers as the other varieties, and the total weight of its tubers was only 55 per cent of that of the other varieties. From each variety 120 tubers of marketable size were taken at random and examined for flea beetle tunnels. The numbers of tunnels per tuber were 164, 163, 104, and 28 for Netted Gem, Burbank, Chippewa, and Doe Bay Red, respectively.

SUMMARY.—A potato variety known locally as Doe Bay Red was found to produce tubers showing resistance to attack by larvae of the tuber flea beetle, *Epitrix tuberis* Gent. Comparative tests with Doe Bay Red and the commercial varieties Chippewa, Netted Gem, White Rose, and Burbank showed that more larvae of this flea beetle developed to maturity in hills of the Doe Bay Red variety, but the tubers of this variety showed consistently less injury from the larvae. This resistance to injury could not be attributed to such differences as tuber set, tuber size, or tuber yield. The Doe Bay Red potato evidently has some undetermined varietal characters that inhibit larval infestation in the tubers.—11-24-47.

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STANLEY F. LIGHT

It is fitting that the JOURNAL should note the death of Professor Stanley F. Light, of the University of California. Professor Light was drowned on June 21, 1947.

At the time of his death Professor Light was a member of the Department of Biology in the University of California. He was best known to entomologists through his work on termites and his comprehensive book on Termites and Termite Control.

Professor Light had ranked as an authority in several rather diverse fields of biology and, in spite of his highly technical work on termites, had never considered himself as an entomologist, probably as a result of the innate modesty which was always noted by his colleagues and students.

Laboratory Tests with Fumigants for Insects Infesting Stored Tobacco

C. O. Bare,[1] *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Laboratory fumigation tests against the cigarette beetle, *Lasioderma serricorne* (F.), and the tobacco moth, *Ephestia elutella* (Hbn.), in stored tobacco were conducted at Richmond, Virginia, from 1944 to 1946, inclusive. The fumigation chamber used for both atmospheric and vacuum treatments was a 33-cubic-foot rectangular steel tank equipped with manometer, recording pressure gauge, thermometer, appropriate valves and graduates for precise measurement and admission of the fumigant, and an exhaust pump operated by electric motor. The heavy steel door of the chamber closed against a rubber gasket and was tightly fastened by screw lugs around its perimeter. At the end of each period of fumigation the exhaust motor was started and the valves to a pipe leading outdoors were opened 10 to 12 minutes to ventilate the chamber. After fumigation the test insects were removed and held until the fifth day before mortality counts were made. Experience showed that insects alive after 5 days would remain alive and active. In all tests nearly grown larvae of the cigarette beetle and the tobacco moth were used.

Tests at Atmospheric Pressure.—A series of tests at atmospheric pressure, replicated 5 times, and at dosages of 1, 1.5, 2, 3, 3.5, 4, 4.5, 5.5, and 6 ounces of fumigant per 1000 cubic feet, was conducted to determine the relative efficiency and safety of acrylonitrile-carbon tetrachloride (50-50 mixture by volume), and of trichloroacetonitrile as compared with that of hydrocyanic acid gas. In each test 50 larvae of the cigarette beetle and 50 of the tobacco moth reared in the laboratory were used. The cigarette beetle larvae were divided into 5 groups of 10 each and placed in open glass dishes. The 50 larvae of the tobacco moth were allowed to remain in the pint glass jars containing corn meal, in which they were reared. The top of each jar was covered with 30-mesh wire screen. Thus the test insects were retained in a convenient location and yet were fully exposed to the fumigant. The liquefied fumigants were carefully measured into a graduate under a chemical hood, and introduced into the fumigation chamber through a valve. Exposure was for approximately 72 hours. Records were maintained of the temperature and other pertinent data during the treatment. All tests were conducted at temperatures between 70° and 82° F. A total of 90 tests were made.

At a 4-ounce dosage hydrocyanic acid gas caused 100 per cent mortality of both insects. The mixture of acrylonitrile-carbon tetrachloride also killed all cigarette beetle larvae at a 4-ounce dosage. A 6-ounce dosage killed 100 per cent of the tobacco moth, but a 4.5-ounce dosage did not. A 6-ounce dosage of trichloroacetonitrile was required to kill both the cigarette beetle and the tobacco moth. From these data it appeared that the order of decreasing effectiveness of these fumigants at the dosages used, was hydrocyanic acid gas, the 50-50 mixture of acrylonitrile-carbon tetrachloride, and trichloroacetonitrile.

Effects of Fumigants on Tobacco.—Since hydrocyanic acid had previously been established as a standard fumigant of the tobacco industry, the safety of the other two fumigants for use on tobacco remained to be determined. A small lot of flue-cured leaf tobacco was placed in the fumigation chamber during one test of acrylonitrile-carbon tetrachloride at the 4.5-ounce dosage and at atmospheric pressure. After 72 hours of exposure the tobacco was allowed to stand for 3 days and then, together with a similar sample of unfumigated tobacco, was submitted to a group of leaf-tobacco experts. They could detect no difference in the aroma, taste, or appearance between the fumigated and the unfumigated tobacco. A similar test was made with trichloroacetonitrile, and again the experts could detect no differences.

Then one bale of Turkish tobacco was exposed to trichloroacetonitrile and

[1] The author wishes to acknowledge the assistance and suggestions of J. N. Tenhet, also of this Bureau.

another to acrylonitrile-carbon tetrachloride. Both were at atmospheric pressure and at a dosage of 16 ounces per 1000 cubic feet for an exposure of 72 hours. Ten days after the tobacco was removed from the fumigation chamber samples were taken from fumigated and unfumigated tobacco, numbered, and submitted to leaf-tobacco experts of a local manufacturing company. They could detect no differences between the fumigated and the unfumigated tobacco. Therefore it was considered safe to proceed with these fumigants on either Turkish or flue-cured tobacco.

PENETRATION OF FUMIGANTS AT ATMOSPHERIC PRESSURE.—The next step was to determine the penetrative properties of these fumigants, since it was known that hydrocyanic acid penetrated stored tobacco very poorly at atmospheric pressure. Bales of Turkish tobacco were used, and nearly mature cigarette beetle larvae were inserted into the tobacco by means of hollow steel test spikes. For each test 25 larvae were placed in each section of a test spike, and 3 spikes were driven into each bale of tobacco. Thus, there were 75 larvae at each depth of 1, 3, 5, 7, and 9 inches in the tobacco. Table 1 summarizes the data obtained from these tests.

With acrylonitrile-carbon tetrachloride tested at atmospheric pressure the 20-ounce dosage at 72-hour exposure, the 28-ounce dosage at 48-hour exposure, and the 32-ounce dosage at 24-hour exposure all gave 100 per cent mortality to depths of 9 inches.

In the tests with trichloroacetonitrile about 50 per cent more trichloroacetonitrile than acrylonitrile-carbon tetrachloride was required to produce the same percentage of mortality. Twenty ounces of acrylonitrile-carbon tetrachloride per 1000 cubic feet were required to produce 100 per cent mortality of cigarette beetle larvae to depths of 9 inches in tobacco, while about 30 ounces of trichloroacetonitrile were necessary to secure the same results. Reed & Vinzant (1942) state that a dosage of 24 ounces per 1000 cubic feet

Table 1.—Results of laboratory fumigation tests at atmospheric pressure and reduced pressure on larvae of the cigarette beetle in bales of Turkish tobacco. (Figures are averages of 5 replications at each dosage.)

Fumigant	Dosage per 1000 Cubic Feet	Exposure Period	Temperature Mean or Range	Per Cent Mortality of Larvae in Tobacco at Depths of—Inches					
				1	2	5	7	9	Check
Tests at atmospheric pressure									
	Ounces	*Hours*	*°F.*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
Acrylonitrile plus carbon tetrachloride (50–50)	16	72	71.1	100	90.8	83.6	84.8	86	8.8
	20	72	72.6	100	100	100	100	100	8
	28	48	76	100	100	100	100	100	0
	28	24	81	100	100	99.6	99.6	99.6	5.6
	32	24	76	100	100	100	100	100	3.2
Trichloroacetonitrile	16	72	76	94.4	60.4	45.6	45.2	44.4	12.8
	20	72	75.7	95.2	79.6	79.6	80.8	80	11.2
	24	72	69.3	100	99.2	98.4	98.4	94.4	4.8
	28	72	73.8	100	100	100	99.6	99.6	16.8
	32	72	69.3	100	100	100	100	100	9.6
Tests at reduced pressure									
Acrylonitrile plus carbon tetrachloride (50–50)	64	3	73–76	100	100	100	100	100	10.4
	32	3	75–86	100	100	100	100	100	1.6
	24	3	72–78	100	100	100	100	100	6.4
	20	3	73–82	100	100	100	100	100	2.4
	16	8	70–79	99.4	99.7	99.7	100	100	7.2
	12	3	70–77	100	100	100	100	100	8
	8	3	70–77	81	77	66.9	70.4	63.7	6.4

of liquid hydrocyanic acid with an exposure of 72 hours is necessary to secure penetration of several inches into tobacco and to produce 100 per cent kills. These tests showed acrylonitrile-carbon tetrachloride to be the most penetrating of the three fumigants compared in these experiments.

TESTS AT REDUCED PRESSURE.—In view of the results obtained with acrylonitrile-carbon tetrachloride at atmospheric pressure, it seemed desirable to determine the minimum dosage of this material which would produce complete mortality of cigarette beetle larvae in vacuum. A series of tests was conducted at a reduced pressure of approximately 28 inches on a mercury gauge with this fumigant at dosages of 64, 32, 24, 20, 16, 12, and 8 ounces per 1000 cubic feet. Each test was replicated 5 times. The same plan of using bales of Turkish tobacco and hollow steel spikes containing cigarette beetle larvae was used in the previously described atmospheric fumigation tests. Larvae of the cigarette beetle were placed in the tobacco at depths of 1, 3, 5, 7, and 9 inches. A total of 1875 larvae were used in the 5 replications at each dosage.

As shown in table 1, at temperatures above 70° F., and with a 3-hour exposure in vacuum, a dosage of acrylonitrile-carbon tetrachloride (50-50) of 20 ounces per 1000 cubic feet was necessary to produce 100 per cent mortality of large cigarette beetle larvae to a depth of 9 inches in bales of Turkish tobacco. The dosage of hydrocyanic acid for vacuum fumigation of tobacco recommended by Reed & Vinzant (1942) was 3 to 5 pounds per 1000 cubic feet.

These laboratory tests indicate that acrylonitrile-carbon tetrachloride (50-50) may be a very promising fumigant for stored tobacco. Its warning odor to the operator is better than that of hydrocyanic acid gas. Preliminary tests indicated that it was safe to use on tobacco, and it was effective against larvae of the cigarette beetle at a dosage of 20 ounces per 1000 cubic feet in either atmospheric or vacuum fumigation. Its penetrative properties are particularly interesting. At atmospheric pressure it produced 100 per cent mortality of cigarette beetle larvae to depths of 9 inches in bales of Turkish tobacco. At comparable dosages it penetrated better and was more effective than trichloroacetonitrile or hydrocyanic acid.—11-8-47

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DR. LAAKE TO GO TO SOUTH AMERICA

Dr. E. W. Laake, of Kerrville, Texas, has been granted a leave of two and a half months from his duties at the laboratory of the Bureau of Entomology and Plant Quarantine. This is to enable Dr. Laake to cooperate with the American International Association for Economic and Social Development in the establishment of a program for the control of external parasites of livestock in South America.

Dr. Laake is scheduled to leave on March 14 and will stop in Costa Rica at the Turrialba Experiment Station to inform himself on the situation in Costa Rica. From there he will go to Sao Paulo, Brazil, where most of his experimental work will be done.

Returning, Dr. Laake will spend some days in Venezuela where he will start a control program with new insecticides. He plans to return to Kerrville during the last week in June.

Grasshopper Control with Parathion, Benzene Hexachloride, Chlorinated Camphene, and Chlordan

CHARLES H. BRETT and W. C. RHOADES, *Oklahoma Agricultural Experiment Station, Stillwater*

Grasshopper concentrations in Oklahoma are generally in comparatively small areas. Alfalfa fields along creeks or in river valley regions offer a source of green succulent food into which economically important species may move shortly after hatching. The margins of such fields often become heavily infested and are stripped of their foliage as the insects progress toward the center. Concentrations of very high population density occur when alfalfa is cut and grasshoppers move into vegetation left around the margins. Such circumstances offer an opportunity for quick and effective control by means of dusts, sprays, or fogs using certain of the recently developed insecticides. Because of the speed and efficiency with which dusts can be applied and because dusting apparatus is often available in Oklahoma, grasshopper control tests have been made chiefly with this medium. This report covers tests carried on in Oklahoma during the spring and early summer of 1947.

Dusts used in the various treatments included 1 and 2 per cent concentrations of parathion (0, 0-diethyl 0-p-nitrophenyl thiophosphate) 5 and 10 per cent gamma benzene hexachloride, 10 and 20 per cent chlorinated camphene and 5 per cent chlordan.

The earliest test was started near Gate, Oklahoma, June 13, in a long field of alfalfa divided crosswise with irrigation ditches a quarter mile apart. The alfalfa had been cut and removed from the field, resulting in concentrations of grasshoppers in tall weeds along the ditches. These concentrations averaged from 50 to more than 100 per square yard. Grasshoppers present were 95 per cent *Melanoplus bivittatus* nymphs and 5 per cent *M. mexicanus* adults. Each irrigation ditch was used for a different treatment. As is shown in table 1, the temperature was 50° F. with the wind ranging intermittently from 10 to 20 miles per hour when dusts were applied. A six-row power duster was used in dusting tests.

The second test was started July 1 near Billings, Oklahoma. Grasshoppers were moving in on the margins of an 80-acre alfalfa field located near a creek. The population density ranged from 20 to 50 grasshoppers per square yard and included 95 per cent *M. differentialis* nymphs, 3 per cent *M. bivittatus* adults and 2 per cent *M. mexicanus* adults. Test plots were laid out along the creek side of the field. As is shown in table 1, the temperature was 83° F. with little air movement when dusts were applied.

Tests using an insecticidal fog apparatus were started July 24 at Stillwater, Oklahoma. The grasshoppers were concentrated in a 20-acre alfalfa field located below a dam and between two creeks. The population density averaged from 15 to 35 grasshoppers per square yard and included 75 per cent *Melanoplus differentialis* nymphs, 20 per cent *M. differentialis* adults, and 5 per cent *M. mexicanus* adults. About two acres were treated with three pounds of chlordan concentrate in 3 gallons of No. 2 diesel oil and about two acres with 5 gallons of water containing 2 per cent gamma benzene hexachloride. Air temperature at the time of application was 100° F. with an intermittent breeze.

The effectiveness of all treatments was measured at regular time intervals. From 2 to 4 different observers were each supplied with a square yard frame. This was dropped at random and counts of live, affected, and dead grasshoppers within the frame were made. Ten to twelve such samples were taken in each plot at the end of each time period. The averages of these measurements for tests with dusts are shown in table 1.

RESULTS.—Parathion dusts were used with considerable caution. At first the operators were very sensitive to even the slightest amounts of drift from this material. Its onion-like odor seemed strong, and a slight burning of the eyes and soreness of the throat was experienced. After the dust had been handled several times, this sensitivity was reduced considerably. The odor became less offensive, and no throat or eye irritation was felt, although a peculiar taste occurred in the mouth. No known injury ever resulted from using the

Table 1.—Comparative effectiveness of different insecticides on grasshoppers in the field, applied as dusts with a six-row power duster. Oklahoma, 1947.

Insecticide Pounds Per Acre	Acres in Treated Plot	Conditions During First 8 Hours		Percentage of Grasshoppers per Square Yard									
				Hours after Treatment									
				4		8		24		102		144	
		Air Temp.	Wind M.P.H.	Affected	Dead	Affected	Dead	Affected	Dead	Affected	Dead	Affected	Dead
Parathion													
2 per cent													
20	1	50°–60°F.	10–20	22.3	63.6	7	92	7.3	91	—	—	0.2	95
10	2	83°–92°F.	0–5	16	79	5	95	3	97	0	90–95	—	—
1 percent													
20	1	50°–60°F.	10–20	42.9	0	49.2	11.2	10.4	8	—	—	0	10
10	2	83°–92°F.	0–5	23	38	14	63	12	80	0	80–90	—	—
(Gamma) Benzene Hexachloride													
10 per cent													
50	1	50°–60°F.	10–20	91.7	5.3	2	98	0	100	—	—	0	100
5 per cent													
10	1	50°–60°F.	10–20	73.5	10	17.7	72.3	8	74.5	—	—	0	75
10	2	83°–92°F.	0–5	33	66	24	69	6	92	0	90–95	—	—
Chlorinated Camphene													
20 per cent													
40	1	50°–60°F.	10–20	39.3	0	31.3	32.1	47.2	22.1	—	—	2	90
10	2	83°–92°F.	0–5	4	0	33	26	55	32	0	50–60	—	—
10 per cent													
40	1	50°–60°F.	10–20	41.5	0	44.8	39	46.7	34.5	—	—	0.7	85
10	2	83°–92°F.	0–5	7	0	26	21	60	29	0	50–60	—	—
Chlordan													
5 per cent													
10	2	83°–92°F.	0–5	9	0	34	14	46	33	?	50–60	—	—

dust. This material was applied to many types of plants without showing phytotoxicity. Six applications of a 5 per cent concentration used on cotton at the rate of 30 pounds per acre at each dusting caused no harm to the plants.

Table 1 shows parathion to be quite sensitive to temperature.[1] The 1 per cent dust was ineffective at 50° to 60° F. but gave good control at 83° to 92° F. even at a lower rate of application; and at the lower temperatures many affected grasshoppers recovered. The speed with which grasshoppers were affected and killed was greater than with any of the other materials tested. At the higher temperatures, 2 per cent dust at 10 pounds per acre, had nearly reached its peak kill by the end of 8 hours. All grasshoppers were affected or dead after 24 hours. There appeared to be some residual action where the 2 per cent dust was applied at 20 pounds per acre at the lower temperatures, although very few grasshoppers moving into the test plot after 6 days showed symptoms of poisoning. Many ground beetles were affected or dead at the end of this time. The number of affected beetles at the end of 6 days indicated the probability that their feeding on dead poisoned grasshoppers was responsible for this.

Benzene hexachloride dust used in 1947 was superior to the technical grade material which was diluted with talc and used in 1946. Table 1 shows this material also is sensitive to temperature. When dust was applied at 83° F., 92 per cent of the grasshoppers were dead by the end of 24 hours as compared with 74.5 per cent when dust was applied at 50° F. However, this was complicated by wind at the lower temperature. In 1946 it was found that increasing the gamma content increased the effectiveness of dusts. This was further demonstrated during the present season, when 98 per cent of the grasshoppers were killed by the end of 8 hours with a dust containing 10 per cent gamma applied at the rate of 50 pounds per acre. It appears that a dust containing 5 per cent gamma benzene hexachloride is of about the same effectiveness as a dust containing 2 per cent of the parathion compound except that benzene hexachloride is somewhat slower acting. The

[1] Laboratory tests showed very little difference in the susceptibility of *M. birittatus* and *M. differentialis* nymphs to the different insecticidal dusts used in these experiments, under the same conditions of temperature.

effect of both materials appears to be largely by contact and both gave excellent control at 10 pounds per acre.

Chlorinated camphene when applied as a dust gave good control by the end of 6 days. Its action was slow. High temperatures appeared to favor it but not to as great an extent as for parathion or benzene hexachloride. Twenty per cent chlorinated camphene dust was but slightly more effective than the 10 per cent dust. Table 1 shows that poor results were obtained at the end of 5 days in the test made at the higher temperatures. This was probably due to rain, which started on the third day after dusts were applied and continued intermittently for three days. Total effectiveness of chlorinated camphene appears to depend upon contact and accumulative stomach action by feeding.

Chlordan dusts prepared by impregnating talc with a technical concentrate and applying it in alfalfa, which had been severely defoliated by grasshoppers gave very poor results in 1946. Weinman & Decker (1947) reported this same situation. Dust used this season contained 5 per cent chlordan. Like the chlorinated camphene, it was slow acting. Thirty three per cent of the grasshoppers were dead by the end of 24 hours. Many were affected. Rain was also the probable reason why this material did not give better results. Chlordan also appears to depend upon both contact and stomach poisoning. If plants do not have sufficient foliage to retain the dust where it will be picked up by feeding grasshoppers, or if strong winds or rain carry the dust away, its effectiveness may be greatly lessened. Weinman *et al.* (1947) have shown that chlordan is most satisfactory when used as a spray. Applied in this manner its action as a stomach poison would be utilized to the greatest advantage.

When using fogs, more of the insecticide appeared to drift away than would have if dusts or sprays were used. Action on the grasshoppers was probably mostly by contact. Benzene hexachloride had killed 81 per cent of the grasshoppers by the end of 24 hours while chlordan had killed 26 per cent of them by the end of 72 hours. The use of fog as a means of application did not seem to be the most satisfastory method.

DISCUSSION.—Grasshopper control has progressed with the development of new insecticides. Their use, however, offers many problems. Such materials as benzene hexachloride and the recently developed parathion which kill largely by contact may be used to an advantage in dusts. Power dusters of modern design using a side delivery attachment will treat areas such as creek banks and fence rows quickly and efficiently. Insecticides which act largely as stomach poisons may be most satisfactory as sprays, since they will be less readily lost from the plants before peak effectiveness is reached.

SUMMARY.—Grasshopper control tests in Oklahoma during 1947, using newly developed insecticides, are reported.

Parathion applied as a 2 per cent dust at 10 pounds per acre, killed 95 per cent of the grasshoppers in an alfalfa field by the end of 8 hours. Five per cent gamma benzene hexachloride at 10 pounds per acre gave approximately the same control by the end of 24 hours. Results of tests conducted at high and low temperatures showed the effectiveness of these materials to be favored by high temperature.

Chlorinated camphene and chlordan dusts were slower in their action. Contact, and feeding of the grasshoppers with subsequent stomach poisoning, appeared to be important in their total effectiveness. Rain, washing these materials from the plants reduced their effectiveness.

Chlordan and benzene hexachloride were applied as fogs. This method did not appear to be as satisfactory as the use of dusts. Much material was lost in drift. Benzene hexachloride was superior to chlordan in its contact action when applied as fog.—11-17-47.

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Benzene Hexachloride Mixtures to Control Four Cotton Insects[1]

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Experiments with benzene hexachloride mixtures for control of the boll weevil, *Anthonomus grandis* Boh., the cotton aphid, *Aphis gossypii* Glov., the tarnished plant bug, *Lygus oblineatus* (Say), and the cotton leafworm, *Alabama argillacea* (Hbn.), were conducted in cages and in field plots at Tallulah, La., during 1946. Benzene hexachloride was mixed with either pyrophyllite or calcium arsenate to obtain different percentages of the gamma isomer.

The method of conducting cage tests was briefly as follows: A cloth hood 4 by 4 by 4 feet was placed over a cotton plant. The dust was then discharged into the hood. The hood was allowed to remain over the plant for several minutes. All insecticides and mixtures were applied at the rate of 8 pounds per acre, with the exception of sulfur, which was applied at the rate of 16 pounds per acre. Screen-wire cages measuring 18 by 18 by 24 inches and 4 by 4 by 4 feet were used in the tarnished plant bug tests and the leafworm tests, respectively, and both sizes were used in the boll weevil tests. The cages were placed over the plants and the insects were released in them immediately or shortly after the dusting was completed. In case of rain the plants were not always redusted. Counts for dead and live insects were usually continued for 4 days after dusting, but sometimes the period was shorter. The net mortalities were computed by Abbott's formula.

There was a highly significant correlation between the percentage of gamma isomer in the benzene hexachloride mixtures and the net mortality of both tarnished plant bug adults and boll weevils (Table 1). Against the tarnished plant bug adults the 1.44 per cent mixture gave a fairly satisfactory control. However, against the boll weevil the 2.88 per cent mixture was required to obtain a mortality equal to that obtained with calcium arsenate.

Table 1.—Cage tests against tarnished plant bug adults and boll weevils with benzene hexachloride dusts containing different percentages of the gamma isomer.

Per Cent of Gamma Isomer in Dust	Per Cent Net Mortality	
	Tarnished Plant Bugs	Boll Weevils
5.75	98	77
2.88	86	65
1.44	78	41
.72	43	32
.36	17	22
.18	12	15
.09	11	13
.04	3	18
Sulfur	7	—
Calcium arsenate	—	64
Minimum significant difference at 5 per cent level	8	16

In cage tests the mixtures of calcium arsenate and benzene hexachloride gave no better control of the boll weevil than calcium arsenate alone (Table 2), and there were no significant differences between any of the treatments. Against the tarnished plant bug, a benzene hexachloride dust containing 1.44 per cent of the

Table 2.—Cage tests against tarnished plant bug adults and boll weevils with mixtures of benzene hexachloride and calcium arsenate containing different percentages of the gamma isomer.

Per Cent of Gamma Isomer in Mixture	Per Cent Net Mortality	
	Tarnished Plant Bugs	Boll Weevils
1.44	26	56
.72	10	55
.36	22	60
.18	20	50
.09	16	57
.04	16	49
Sulfur	13	—
Calcium arsenate	—	62

[1] Presented at the annual meeting of the Cotton States Branch of the American Association of Economic Entomologists at Biloxi, Miss., January 15–17, 1947.

[2] The writers were assisted in the field by A. L. Scales, G. L. Garrison, G. L. Smith, Jr., W. E. Benjamin, V. O. Spharler, S. C. Bray, E. B. Frierson, R. W. Goza, and V. J. Colligan.

Table 3.—Cage tests against tarnished plant bug adults and boll weevils with seven brands of benzene hexachloride.

Insecticide	Per Cent of Active Ingredient	Per Cent Net Mortality: Tarnished Plant Bugs	Per Cent Net Mortality: Boll Weevils	
Benzene hexachloride:				
No. 1	5	98	66	—
	2.5	—	—	63
2	5	99	65	—
	2.5	—	—	58
3	5	95	53	—
	2.5	—	—	55
4[1]	2.88	92	54	—
	1.44	—	—	35
5	5	96	55	—
	2.5	—	—	30
6	5	94	49	—
	2.5	—	—	35
7	5	94	49	—
	2.5	—	—	35
DDT in pyrophyllite	5	52	18	—
Sulfur	—	6	—	—
Calcium arsenate	—	—	53	—
	—	—	—	59
Minimum significant difference at 5 per cent level	—	10	20	19

[1] When this material was submitted for tests, the manufacturer advised that it contained 10 per cent of the gamma isomer. However later information indicated that the material contained only 5.75 per cent of the gamma isomer.

gamma isomer gave a mortality of 78 per cent (Table 1) whereas when calcium arsenate was included in the dust the mortality was only 26 per cent (Table 2).

Samples of benzene hexachloride furnished by seven manufacturers were tested in cages (Table 3). Six mixtures containing 5 per cent of the gamma isomer and one containing 2.88 per cent were used against the tarnished plant bug. Six mixtures containing both 5 and 2.5 per cent of the gamma isomer and one containing 2.88 and 1.44 per cent were used against the boll weevil. All the 5 per cent mixtures and the one containing 2.88 per cent were equally effective against both insects, but there were significant differences between the 2.5 and 1.44 per cent mixtures against the boll weevil. Three of the materials gave about the same boll weevil mortalities at both strengths, but the other four at the 2.5 and 1.44 per cent strengths gave considerably lower mortalities. These records seem to indicate that the actual gamma isomer content of some of the materials varied from that reported by the manufacturer.

In cage tests against cotton leafworms benzene hexachloride containing 2.88 per cent of the gamma isomer gave a net mortality of 80 per cent compared with 86 per cent from the use of calcium arsenate.

In a field-plot experiment (Table 4) where five applications of the various treatments were made every 7 days from July 18 to August 15 with rotary hand

Table 4.—Effectiveness of benzene hexachloride dusts containing different percentages of the gamma isomer, and of calcium arsenate with and without nicotine, against the boll weevil and the cotton aphid in 0.20-acre field plots. Four replicates in randomized blocks.

Treatment	Average Pounds of Insecticide per Acre	Per Cent of Squares Punctured by Boll Weevil: Maximum on Aug. 8	Per Cent of Squares Punctured by Boll Weevil: Average	Number of Aphids per Square Inch[1]: Maximum on Aug. 28	Number of Aphids per Square Inch[1]: Average	Yield of Seed Cotton, Pounds per Acre
Benzene hexachloride, per cent of gamma isomer:						
5.75	7.0	75	64	0.38	0.15	566
2.88	6.8	80	71	.81	.36	438
1.44	7.2	78	72	3.93	1.20	399
Calcium arsenate plus nicotine 1 per cent	6.4	90	77	20.03	6.02	468
Calcium arsenate	7.2	85	77	55.81	17.00	543
Check (no treatment)	—	89	82	16.13	4.77	373
Minimum significant difference at 5 per cent level	—	10	9	8.53	2.10	108

[1] Counted on underside of the fourth leaf from the top of the plants.

Table 5.—Effectiveness of mixtures of benzene hexachloride and calcium arsenate containing different percentages of the gamma isomer, and of calcium arsenate with and without nicotine, against the boll weevil and the cotton aphid in ¼-acre field plots. Four replicates in randomized blocks.

Treatment	Average Pounds of Insecticide per Acre	Per Cent of Squares Punctured by Boll Weevil		Number of Aphids per Square Inch[1]		Yield of Seed Cotton, Pounds per Acre
		Maximum on Aug. 5	Average	Maximum on Aug. 19	Average	
Calcium arsenate and benzene hexachloride, per cent of gamma isomer:						
1.44	6.5	66	38	30.72	14.27	669
.72	6.9	66	39	27.44	12.47	724
.36	6.4	68	33	22.59	10.31	768
Calcium arsenate plus nicotine 1 per cent	6.4	70	33	22.90	10.38	761
Calcium arsenate	6.7	62	33	33.10	13.16	789
Check (no treatment)	—	88	56	22.96	8.91	502
Minimum significant difference at 5 per cent level	—	—	9	—	3.12	155

[1] Counted on underside of the fourth leaf from the top of the plants.

guns, benzene hexachloride mixtures containing 5.75 per cent of the gamma isomer gave significantly better control of the boll weevil than did calcium arsenate, whereas the 2.88 and 1.44 per cent mixtures and calcium arsenate were equally effective. All three benzene hexachloride mixtures gave excellent control of the cotton aphid. The results indicate that the interval between insecticide applications should be less than 7 days, since satisfactory control of the boll weevil was not obtained in this experiment. The only two treatments which caused a significant increase in yield over the check were calcium arsenate and the 5.75 per cent gamma benzene hexachloride. In similar field-plot tests with mixtures of calcium arsenate and benzene hexachloride (Table 5), the yields were no better than with calcium arsenate alone.

In field tests against heavy infestations of cotton aphids there was a significant correlation between the gamma isomer in the benzene hexachloride mixture and the percentage reduction of cotton aphids (Tables 6 and 7). Dosages of 4 ounces or more of gamma isomer per acre were required to give consistently satisfactory control of heavy infestations.

In laboratory tests vapors given off by benzene hexachloride killed boll weevils, cotton aphids, tarnished plant bugs, and leafworms. These tests indicated that the material is a fumigant.

Red spiders were more numerous on cotton which had been dusted several times with benzene hexachloride than on cotton dusted with other insecticides or on untreated cotton. Benzene hexachlo-

Table 6.—Field tests against the cotton aphid with benzene hexachloride mixtures containing different percentages of gamma isomer applied at different dosages.

Per Cent of Gamma Isomer	Application on Aug. 22, Pounds per Acre		Area of Plot, Acre	Number Aphids per Square Inch on Aug. 21	Per Cent Reduction	
	Mixture	Gamma Isomer			Aug. 26	Aug. 30
1.00	17	.17	1	47	45	72
2.88	8	.23	½	81	82	79
1.44	18	.26	½	56	66	88
2.88	14	.40	¼	81	95	95
2.88	24	.69	¼	81	—	97

Table 7.—Field tests against the cotton aphid with benzene hexachloride containing different percentages of gamma isomer applied at different dosages on 1-acre plots. (17 aphids per square inch on Aug. 8.)

Per Cent of Gamma Isomer	Application on Aug. 9, Pounds Pet Acre		Per Cent Reduction		
	Mixture	Gamma Isomer	Aug. 12	Aug. 14	Aug. 17
.50	10.5	.05	7	0	0
1.00	12.5	.12	55	38	20
1.44	11.0	.16	61	25	47
2.88	13.0	.37	90	86	94
5.75	10.0	.57	80	71	87

ride, when applied to cotton, killed many beneficial insects.

The results of these experiments indicate that benzene hexachloride should not be mixed with regular calcium arsenate. Although benzene hexachloride appears to possess outstanding insecticidal properties, much additional information is needed about dosage, intervals between applications, time of application, and many other factors before recommendations for its use can be made. Information is also needed on the toxicity to cotton insects of the several isomers, alone and in combinations.—11-20-47

Benzene Hexachloride to Control Boll Weevil and Cotton Aphid

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In 1945 the authors conducted field-plot tests at the Delta Branch Experiment Station, Stoneville, Mississippi, against the cotton aphid, *Aphis gossypii* Glov., with benzene hexachloride dusts containing approximately 0.23 per cent of the gamma isomer in three different carriers. The first carrier tested was commercial grade calcium arsenate, the second was a high-test calcium arsenate with reduced free-lime content, and the third was dusting sulfur. When single applications were made to heavily infested dry cotton, the first and second mixtures failed to hold the aphid population to a level with the checks. The increase of population was greater following the use of the mixture with the usual commercial grade of calcium arsenate than following the use of the high-test calcium arsenate. The mixture containing dusting sulfur gave a considerable reduction in the aphid population by the end of 3 days. In 1945 Ivy & Ewing (1946) found benzene hexachloride dusts to be very toxic to the boll weevil, *Anthonomus grandis* Boh., and to the cotton aphid.

During 1946 the authors conducted additional tests with benzene hexachloride dusts against the boll weevil and the cotton aphid in the Stoneville area, where no other cotton pests were considered to be of economic importance. The primary purposes of these experiments were to compare benzene hexachloride with calcium arsenate for boll weevil control, to compare benzene hexachloride with nicotine for aphid control, and to determine the compatibility of benzene hexachloride and calcium arsenate. Provision was also made for comparing the effectiveness of nicotine derived from two sources for aphid control.

METHODS.—The study consisted of three randomized-block experiments replicated four times. All insecticides were applied with rotary hand guns. The boll weevil infestation records were obtained by examining 100 squares in each plot. The aphid-population counts were made by examining 1 square inch on the under side of the fourth leaf from the top of each of 100 plants in each plot. Yield records were obtained by picking the open cotton, either two or three times, from entire plots.

EXPERIMENT 1.—Each of 40 plots in this experiment was 10 rows wide and 133 feet long, and contained 0.1 acre. There were nine treatments and a check (Table 1). Formulations of benzene hexachloride at three gamma-isomer concentrations in a diluent were tested. To test the com-

[1] Willie Ray Smith and Lloyt Faulkner assisted with this investigation.

[2] In cooperation with the Mississippi Agricultural Experiment Station.

Table 1.—Effect of various benzene hexachloride and calcium arsenate treatments on cotton aphids and boll weevils and yield of seed cotton.

Treatment	Average per Acre Application of Insecticides	Aphids per Square Inch of Leaf Area		Boll Weevil Infestation		Average Yield per Acre	Gain Over Check
		Maximum	Average	Maximum	Average		
	Pounds	*Number*	*Number*	*Per Cent*	*Per Cent*	*Pounds*	*Pounds*
Experiment 1							
Check (no treatment)	—	0.94	0.51	78	66	1884	—
Benzne hexachloride (10 per cent gamma) 50 per cent, clay 50 per cent	6.6	.02	.02	41	33	2102	218
Benzene hexachloride (10 per cent gamma) 25 per cent, clay 25 per cent, pyrophyllite 50 per cent	6.4	.04	.03	59	48	1923	39
Benzene hexachloride (10 per cent gamma) 5 per cent, clay 5 per cent, pyrophyllite 90 per cent	6.6	.83	.04	64	51	1903	19
Benzene hexachloride (10 per cent gamma) 25 per cent, calcium arsenate 75 per cent	6.5	.06	.04	46	38	2036	152
Benzene hexachloride (10 per cent gamma) 10 per cent, calcium arsenate 90 per cent	7.1	1.09	.70	34	31	2020	136
Benzene hexachloride (10 per cent gamma) 25 per cent, calcium arsenate 37.5 per cent, sulfur 37.5 per cent	7.0	.03	.02	44	37	1988	104
Calcium arsenate 95 per cent, plus nicotine 1 cent in the form of sulfate	6.8	.08	.07	43	35	2101	217
Calcium arsenate 96 per cent, plus nicotine 1 per cent from zinc nicotinyl fluosilicate	6.8	.29	.15	46	38	2040	156
Calcium arsenate	6.6	2.76	1.42	48	37	2029	145
Minimum significant difference:							
5 per cent level	—	—	—	—	7.05	—	—
1 per cent level	—	—	—	—	9.53	—	—
Experiment 2							
Check (no treatment)	—	8.96	4.08	80	71	1642	—
Benzene hexachloride (11.5 per cent gamma) 40 per cent, clay 40 per cent, pyrophyllite 20 per cent	5.6	.45	.13	73	60	1771	129
Benzene hexachloride (11.5 per cent gamma) 25 per cent, clay 25 per cent, prophyllite 50 per cent	5.5	.23	.11	63	61	1652	10
Benzene hexachloride (11.5 per cent gamma) 12.5 cent, clay 12.5 per cent, pyrophyllite 75 per cent	6.0	.38	.18	77	65	1658	16
Calcium arsenate, plus nicotine 1 per cent[1]	5.6	.99	.43	50	49	1850	208
Calcium arsenate	6.0	14.74	7.01	58	55	1772	130
Minimum significant difference:							
5 per cent level	—	—	—	—	12.2	—	—
Experiment 3							
Check (no treatment)	—	18.1	6.7	37	20	1402	—
Calcium arsenate 75 per cent, benzene hexachloride (11.5 per cent gamma) 25 per cent	5.9	28.4	11.0	20	12	1219	183
Calcium arsenate 87.5 per cent, benzene hexachloride (11.5 per cent gamma) 12.5 per cent	5.8	32.7	12.4	22	12	1205	−197
Calcium arsenate 93.75 per cent, benzene hexachloride (11.5 per cent gamma) 6.25 per cent	5.9	25.6	10.8	18	12	1302	100
Calcium arsenate plus nicotine 1 per cent[1]	6.1	24.4	9.0	12	7	1282	−120
Calcium arsenate	6.0	23.3	9.3	17	10	1215	−187
Minimum significant difference:							
5 per cent level	—	—	—	—	—	—	—

[1] A commercial preparation of nicotine sulfate containing not less than 14 per cent of nicotine.

patibility of a commercial grade of calcium arsenate and benzene hexachloride, two mixtures of these insecticides were included. Another mixture containing calcium arsenate, sulfur, and benzene hexachloride was tested. Two calcium arsenate mixtures containing nicotine from different sources were included for comparison in aphid control. The ninth treatment was with commercial grade calcium arsenate.

Insecticides were applied in the after-

noon five times at 4- or 5-day intervals between July 26 and August 14, and a sixth application was made on August 21 for boll protection. Boll weevil infestation records were made six times and aphid counts five times between July 11 and August 22, at approximately weekly intervals. The first two weevil records and the first aphid record, made before dusting was started, were not included in the averages. Cotton was picked three times between August 29 and October 21.

Results indicated that benzene hexachloride containing 5 per cent of the gamma isomer in a diluent was equal to calcium arsenate and 1 per cent of nicotine in boll weevil control. Reductions in the gamma isomer content resulted in a significant decrease in effectiveness.

The two benzene hexachloride-calcium arsenate mixtures, and the benzene hexachloride-calcium arsenate-sulfur mixture gave weevil control equal to that obtained with commercial grade calcium arsenate.

There was strong evidence of a fumigating action from benzene hexachloride, which held the aphid population to an exceedingly low level in all plots, including the nearby plots dusted with commercial grade calcium arsenate.

The plots yielding the most cotton were treated with benzene hexachloride (5 per cent gamma isomer) in a diluent, and calcium arsenate containing 1 per cent of nicotine in the form of sulfate, the increases from these two treatments were not significant. The slight reductions in yield following the other treatments cannot be attributed to boll weevil and aphid infestations.

Plant injury from the use of benzene hexachloride mixtures was exceedingly light. Injury to tender leaves was about the same as that caused by undiluted commercial grade calcium arsenate.

EXPERIMENT 2.—This experiment was designed to compare the effectiveness of benzene hexachloride in a diluent at three gamma-isomer levels (4.6 per cent, 2.875 per cent and 1.4375 per cent) with that of calcium arsenate for boll weevil control when applied at 7-day intervals. Calcium arsenate containing 1 per cent of nicotine was included so that comparisons of aphid control could also be made.

Each of 24 plots was 16 rows wide and 130 feet long, and occupied approximately 0.16 acre. There were five treatments and a check.

Insecticides were applied in the afternoon five times between July 25 and August 22. Boll weevil counts were made five times and aphid counts six times between July 25 and August 28 at weekly intervals. As in the previous experiment, the first weevil record and the first aphid count, made before dusting was started, were not included in the averages.

Since treatments at 7-day intervals do not give such good protection from boll weevils as those at 4- or 5-day intervals, as shown in the first experiment, a time limit in the residual effects of benzene hexachloride is indicated. The benzene hexachloride mixture containing 4.60 per cent of the gamma isomer did not hold the weevil infestation quite so low as did commercial grade calcium arsenate. The yield following the use of this mixture was lower than that following calcium arsenate containing 1 per cent of nicotine, but the differences were not significant.

As in experiment 1, aphid populations were never considered to be of economic importance, except possibly after the use of the commercial grade calcium arsenate.

EXPERIMENT 3.—This experiment was designed to determine whether, with the cotton aphid as an indicator, benzene hexachloride at low gamma-isomer levels was compatible with the usual commercial grade calcium arsenate. Three levels of the gamma isomer (2.775 per cent, 1.4375 per cent and 0.71875 per cent) mixed with calcium arsenate were compared with calcium arsenate containing 1 per cent of nicotine, and with calcium arsenate alone. Each of 24 plots was 14 rows wide and 131 feet long, and contained approximately 0.14 acre. There were five treatments and a check.

Insecticides were applied at 7-day intervals between July 12 and August 23. An extra application made on July 10 was lost by rain within 20 hours. The first three were made in the afternoon, and the last five in the morning when the plants were wet with dew. Boll weevil infestation records were made four times between July 10 and August 21. Aphid counts were made eight times between July 10 and August 28. Boll weevil and aphid records made on July 10, before dusting were not included in the averages.

No aphid control whatsoever was obtained with the benzene hexachloride-calcium arsenate mixtures, and 1 per cent of nicotine in calcium arsenate failed to hold the population below the level obtained with commercial grade calcium arsenate when applied under the above-described conditions.

In this aphid-control experiment poisoning was begun before the boll weevil infestation averaged 0.04 per cent, whereas in the two boll weevil control experiments it was begun when infestations averaged 25 per cent or more. As has been found previously in this locality, poisoning to control light weevil infestations without controlling the aphid has almost invariably resulted in yield losses. Excessive rains caused more than average variance in cotton growth; therefore a great deal of importance, should not be attached to the yield losses in this experiment.

DISCUSSION.—When analyzed by the Geneva method, it was determined that the calcium arsenate used in the first test contained 41.3 per cent of total As_2O_5 and 7.6 per cent of water-soluble As_2O_5, and that used in the second and third tests an average of 43.9 per cent of total As_2O_5 and 5.6 per cent of water soluble As_2O_5.[3]

The benzene hexachloride used in the first experiment was a technical product reported by the manufacturer to contain not less than 10 per cent of the gamma isomer. The benzene hexachloride used in the second and third tests was supplied by another manufacturer and was reported to contain 11.5 per cent of the gamma isomer. Both products were ground with equal parts of a clay diluent before being used. All mixtures containing benzene hexachloride were disagreeable to use because of persistent musty odor and irritating effects on tender skin around the eyes and between the fingers.

No definite explanation is available as to the apparent compatibility of mixtures of benzene hexachloride and calcium arsenate used in the first test and the apparent incompatibility of the mixtures used in the third test. It has been suggested by chemists studying the problem that undue exposure to moisture, during or after mixing, may have resulted in a reaction between the benzene hexachloride and the calcium arsenate mixture used in the third test.

SUMMARY.—Tests were conducted in the area of Stoneville, Mississippi, to compare benzene hexachloride with calcium arsenate and nicotine for the control of the boll weevil, *Anthonomus grandis* Boh., and the cotton aphid, *Aphis gossypii* Glov., respectively.

Benzene hexachloride at a 5 per cent concentration of the gamma isomer was as effective as calcium arsenate for boll weevil control when applied at the same rate per acre at 4- or 5-day intervals. The residual effect of benzene hexachloride in boll weevil control was at least no better than that of calcium arsenate, and a 7-day interval was beyond the range of effectiveness.

Aphids were controlled at a much lower gamma-isomer content than was required to control boll weevils. Additional information is needed before the efficacy of mixing benzene hexachloride and calcium arsenate can be fully determined. The persistent musty odor and irritating effects of benzene hexachloride is a distinct disadvantage, and much additional information is needed before it can be generally recommended.—10-2-47.

[3] All analyses were made by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine.

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Status of Velvetbean Caterpillar Control in Alabama

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The velvetbean caterpillar, *Anticarsia gemmatilis* (Hbn.), causes severe damage to peanuts throughout southeastern Alabama at irregular intervals and causes some damage in Geneva and Houston counties almost every year. Results of control experiments conducted during the outbreaks of 1939 and 1944 have been published by Guyton (1940) and English (1946). The results of experiments conducted in 1946 are herein reported together with a discussion of the DDT spray residue problem.

In 1946 the velvetbean caterpillar first appeared in Houston County along the Chattahoochee River. The first small larvae were collected from kudzu on June 21. By July 2, a few were found on kudzu over most of Geneva and Houston counties. Apparently, peanut vines were not rank enough at that time to attract the adults for egg-laying. The infestation spread northward, and, as peanut vines became denser, the larvae appeared on them. By August 15, counts of 15 to 120 larvae per 2 feet of row were common in Houston and Geneva counties, with somewhat lower counts in other peanut-producing counties.

Control experiments were conducted at the Wiregrass Substation on plots four rows wide and 33.33 feet long. Insecticidal dusts were applied with a rotary-type hand duster; infestation counts of worms were made at intervals; and yield records of peanuts were taken at the end of the experiment. Each test was replicated several times.

DDT.—This experiment was designed to compare the effectiveness of 1-per cent and 3-per cent DDT dust. Treatments were replicated four times. One application of each dust was made August 20 at the rate of about 35 pounds per acre. At this time slight ragging of foliage was in evidence, with an average of 52 larvae per 2 feet of peanut row. Following this dusting the infestation decreased on all plots, including the checks. The average number of caterpillars per 2 feet of row during a 7-day period after dusting on the various plots was as follows: check, 26.2; 3 per cent DDT, 2.1; 1 per cent DDT, 2.5.

The average yield of peanuts on these plots is shown in table 1. All dusted plots produced more peanuts than did undusted ones. Peanuts receiving about 35 pounds per acre of 1-per cent DDT outyielded those receiving the same heavy dose of 3-per cent dust. Peanuts protected by 1 per cent DDT yielded 573 pounds of dry peanuts more per acre than did plants stripped by caterpillars. Where peanuts were ragged but not stripped, the yield differences between dusted and check plots ranged from 122 to 393 pounds of dry peanuts per acre.

Only one digging was made for yield records, and this was done when the Substation Superintendent considered the undusted plots ready for harvest. Experiments in previous years have shown that defoliated peanuts suffer additional losses by heavy shedding of peanuts in the ground where digging is delayed.

CRYOLITE.—The purpose of this experiment was to determine when to begin dusting with cryolite and the number of applications needed for profitable control of the velvetbean caterpillar. DDT and benzene hexachloride were included for comparison. The first dusting was made August 20, when slight ragging of foliage was first in evidence, and there was an average of 63 larvae per 2 feet of row. Too few larvae were present following the first dusting to justify carrying out the entire dusting schedule as planned, but the following cryolite treatments were

Table 1.—Average yield of peanuts dusted once with DDT about 35 pounds per acre, 1496.

Treatment	Lbs. Dry Peanuts per Acre		Remarks
	On Vines	In Ground	
Check 1	1126	175	1 plot stripped 3 ragged
3% DDT	1248	94	No damage
1% DDT	1519	102	No damage
Check 2	946	258	All 4 plots stripped

made: August 20, August 20 and September 2, September. 2 All treatments were replicated four times.

Infestation counts of insects following dusting indicated excellent control on all dusted plots (Table 2) and some reduction in the population on checks, particularly those adjacent to the DDT and benzene hexachloride treatments. Two weeks after dusting with DDT the peanuts were still receiving complete protection against the caterpillar, whereas small larvae were appearing in considerable numbers on plots dusted with cryolite and benzene hexachloride. By harvest time, 4 weeks after dusting, some ragging of foliage was in evidence on all plots except those treated with DDT.

Yield records from this experiment are presented in table 3. Only one of the four undusted plots was completely defoliated; the others were moderately ragged. Nevertheless, the yield of peanuts was considerably lower on the checks than on plots protected by cryolite, DDT, and benzene hexachloride.

A second digging, one week after the first, revealed that plants dusted with DDT continued to mature peanuts and retain them on the vine (Table 3). Plants dusted with benzene hexachloride were beginning to lose peanuts in the ground, although the yield on the vines was still high.

BENZENE HEXACHLORIDE.—After infestation counts had shown benzene hexachloride containing 5 per cent gamma to be highly effective against the velvetbean caterpillar, a small experiment of two replicates was set up to test a dust containing only 1 per cent gamma isomer. One application of dust was made August 21 at the rate of 20 pounds per acre.

Table 3.—Average yield of peanuts on the vines following various treatments, 1946.

TREATMENT	LBS. DRY PEANUTS PER ACRE		REMARKS
	1st digging	2nd digging[1]	
Check	901	—	1 plot stripped 3 ragged
Cryolite, Aug. 20	1324	—	No damage till late
Cryolite, Aug. 20, Sept. 2	1198	—	No damage
Cryolite, Sept. 2	1123	—	Ragging early
3% DDT, Aug. 20	1114	1270	No damage
5% gamma benzene hexachloride, Aug. 20	1323	1359	Slight ragging late

[1] Dry weights on second digging approximate; estimated from green weights on basis of average shrinkage during drying.

The dusted plots were well protected and produced 304 pounds of dry peanuts per acre more than the checks, which were not completely defoliated.

DEFOLIATED PEANUTS.—An experiment was conducted to determine the effect of dusting after the peanuts had been defoliated by the velvetbean caterpillar. For this test, a field was selected in which less than 10 per cent of the leaves remained on the plants. Dusts were applied at the rate of 20 pounds per acre on 3 replicates of plots. The first application, made August 28, was washed off within a few hours by a 2-inch rain and was repeated. Good control of the velvetbean caterpillar resulted. Much new foliage was in evidence on all dusted plots by September 2. At this time hungry larvae were migrating to the dusted plots from the checks and other undusted peanuts. Heavy rains had prevented the maintenance of furrows to stop migration. An application of dust was made to protect the newly formed leaves and furrows were opened to prevent further damage from migrating larvae.

Table 2.—Average number of caterpillars per two feet of peanut row, cryolite experiment, 4 replications, 1946.

TREATMENT	NUMBER OF CATERPILLARS					
	Aug. 19[1]	Aug. 21	Aug. 23	Aug. 28	Sept. 3	Average Aug. 21–Sept. 3
Check	65.3	38.0	33.2	51.2	41.0	40.8
Cryolite, Aug. 20	65.3	7.5	3.2	13.2	10.3	8.5
Cryolite, Aug. 20, Sept. 2	65.3	6.0	1.0	10.0	7.5	6.1
Cryolite, Sept. 2	65.3	—	35.0	45.3	23.2	34.5
DDT, 3%, Aug. 20	65.3	1.3	0.5	1.0	1.5	1.1
Benzene hexachloride, 5% gamma, Aug. 20	65.3	1.7	0.0	0.0	33.5	8.8

[1] Average caterpillar count over experimental area before plots were laid off.

Under the adverse conditions of this experiment, cryolite gave better control than 1 per cent DDT or benzene hexachloride containing 1 per cent gamma isomer (Table 4). All dusted plants retained their peanuts better than those on the checks, especially where digging was delayed one week.

DISCUSSION OF RESULTS.—DDT, cryolite, and benzene hexachloride were effective in controlling the velvetbean caterpillar. DDT protected peanuts against damage over the longest period of time; protection given by benzene hexachloride was the shortest.

The highest increase in yields occurred on plots where dust was applied early, before serious ragging of leaves occurred. Dustings made 2 weeks later, after moderate to severe ragging occurred, resulted in yields intermediate between complete protection and no protection from worms.

Complete protection from caterpillar damage resulted in increased yields of 302 to 573 pounds of air-dried peanuts per acre on land producing 946 pounds without protection. The peanuts were dug before much loss from shedding in the ground had occurred. Experiments in previous years have shown that on defoliated plants a high percentage of the peanuts produced were lost in the ground where digging was delayed. Thus, protecting peanuts against caterpillar injury enables the plants to produce a good crop and retain the peanuts without serious loss from shedding.

Under the conditions of the experiment dusting was profitable even after peanuts had been defoliated by the velvetbean caterpillar.

Rates of dust applications varied in different experiments. One per cent DDT at 20 pounds per acre appeared somewhat less effective than cryolite under very adverse conditions of insect migration. At about 35 pounds per acre, 1 per cent DDT gave excellent control over a period of 4 weeks.

Benzene hexachloride containing 1 per cent gamma isomer applied at 20 pounds per acre gave good control in one experiment. In another, it was less effective than cryolite under conditions of insect migration. At 5 per cent gamma content, benzene hexachloride gave excellent results. It appears that a 2 per cent dust used at the rate of 20 pounds per acre would be satisfactory. The expensiveness of benzene hexachloride and its disagreeable properties are the chief disadvantages of the material. Its short period of effectiveness would indicate the absence of a serious residue problem.

Cryolite at 20 pounds per acre and above gave excellent control but did not protect peanuts as long as DDT. Cryolite is more expensive than DDT; the price, however, is not prohibitive.

DDT SPRAY RESIDUE.—The cheapness and effectiveness of DDT make it a desirable insecticide from the standpoint of velvetbean caterpillar control. Certain possible dangers exist, however, in the use of DDT on such hay crops as peanuts. The DDT tends to persist on the plants even after rain.

Data on the amount of DDT on hay from peanuts dusted for caterpillar control in 1946 are presented in table 5. In eight of the 13 samples of hay analyzed, the DDT residue was in excess of the 7 ppm tolerance established by the U. S. Food and Drug Administration as the amount allowed on certain food products. Three of five samples below the tolerance had been processed through the peanut picker and hay baler. All five samples were from fields on which approximately 6 inches of rain fell over the 4 to 5-week period between dusting and harvest. Another sample of hay contained DDT 40 per cent in excess of the tolerance after processing through the picker and baler. This sample was from an area that had 4.2 inches of rainfall over a 30-day period between dusting and harvest. Thus, it is evident that some DDT persisted on peanut foliage for several weeks after the dust was applied. It appeared that most of the DDT was removed from the foliage by the combined action of (1) weathering

Table 4.—Average yields of peanuts on plants defoliated by velvetbean caterpillar before dusts were applied 20 lbs. per acre, 1946.

TREATMENT	POUNDS DRY PEANUTS PER ACRE			
	1st Digging		2nd Digging*	
	On Vines	In Ground	On Vines	In Ground
Check	1405	440	699	954
Cryolite	1624	298	1232	571
DDT, 1%	1590	352	1222	704
Benzyne hexachloride, 1% gamma	1489	323	1032	738

* Dry weights on second digging approximate; estimated from green weights on basis of average shrinkage during drying.

Table 5.—Amount of DDT residue on peanut hay, 1946.

NO. OF DUSTINGS	DUST PER ACRE[2]	DDT IN DUST	DAYS, LAST DUSTING TO HARVEST	RAINFALL, LAST DUSTING TO HARVEST	HAY PROCESSED	DDT ON HAY PPM
1	20 lbs.	3%	1	0.0 in.	No	31
1	20	3	13	1.8	No	20
1	35	3	17	1.9	No	25
1	35	1	17	1.9	No	11
4	20	3	37	5.3	No	18
1	20	3	23	5.3	No	14.1[1]
1	20	3	35	6.2	Yes	4.2[1]
1	20	3	35	5.9	No	6.0[1]
1	20	3	35	5.9	Yes	2.0[1]
1	40	3	26	6.1	No	10.3[1]
1	20	3	29	5.9	No	4.3[1]
1	20	3	28	5.9	Yes	4.2[1]
1	20	3	30	4.3	Yes	9.0[1]

[1] Analyses by U.S.D.A., Bureau of Entomology and Plant Quarantine.
[2] Each application.

over a period of 4 to 5 weeks, during which time there was approximately 6 inches of rainfall, and (2) the processing of hay through the picker and baler. Where the interval between dusting and harvest was less than 4 weeks, where the rainfall was less than 5 inches, or where the peanut vines were not processed through a picker and baler, considerable residue of DDT was found on the hay, the amount present usually exceeding the tolerance of 7 ppm.

Feeding experiments have been conducted at the Agricultural Experiment Station and elsewhere to determine the effect of feeding DDT-treated hay and corn to livestock. The work at this Station was conducted by the departments of Animal Husbandry[1] and Zoology-Entomology in cooperation with the U. S. Bureau of Entomology and Plant Quarantine. Some results of these experiments are given here.

1. Hay containing 184 ppm of DDT was fed to cattle for 90 to 105 days. Steers at slaughter contained 60 to 160 ppm of DDT in the fat. Cows passed 10 to 36 ppm in the milk. The milk exposed to laboratory-reared houseflies in cages resulted in 93 per cent mortality of flies in 48 hours as compared with no mortality in the checks.[2] A calf suckled by a cow receiving DDT-dusted hay stored 825 ppm in its fatty tissue.

2. A steer fed 143 days on hay containing 48 parts DDT per million parts of hay stored 80 to 88 ppm in the fat of the animal.

3. Two steers fed 105 days on unshucked corn containing DDT, 15 ppm,[3] stored 46 to 65 ppm in the fatty tissues; pigs in 102 days stored only 13 ppm.

All animals receiving the DDT-treated feed appeared normal, but contained enough DDT to be considered unfit for human food according to U. S. tolerance of 7 ppm. The large amount of DDT in the milk of cows and the enormous quantity stored in the fat of calves reared on the milk indicate the peculiar hazards of feeding hay containing DDT to dairy cattle. The health of children consuming large quantities of the milk might be endangered.

Hay produced from peanut vines dusted with DDT for control of the velvetbean caterpillar contains considerably less DDT than the hay fed in experiments at Auburn. However, if sufficient weathering has not taken place between dusting and harvesting of peanuts it may contain DDT in excess of the federal tolerance for certain foods.

SUMMARY.—Experiments in the control of the velvetbean caterpillar, *Anticarsia gemmatilis* (Hbn.), were conducted on the Wiregrass Substation during a major outbreak of the pest on peanuts in 1946. Single applications of DDT, cryolite, or benzene hexachloride to replicated plots of peanuts gave protection against serious insect damage from August 20 to harvest, September 19. Infestation counts revealed that DDT was effective over the longest period of time and benzene hexachloride the shortest.

Dusted plots produced higher yields than those not dusted. In one experiment where dusts were applied at the rate of 35 pounds per acre, the average yields on various plots were as follows: Check, 946 pounds of dry peanuts per acre; 1 per cent DDT, 1519 pounds; 3 per cent DDT, 1248 pounds. In another experiment where the peanuts on the checks were ragged but not defoliated, the average per acre yields were as follows: Check, 901 pounds; cryolite, 1123 to 1324 pounds, depending upon the time of application; 3 per cent DDT, 1114 pounds; 5 per cent gamma benzene hexachloride, 1323

[1] Animals were fed by M. J. Burns and analyses of animal tissues were made by Dr. W. C. Sherman, Mr. Burns, and the U. S. Bureau of Entomology and Plant Quarantine.
[2] Test by Dr. L. L. English, formerly Entomologist, Alabama Agricultural Experiment Station.
[3] The corn was treated with DDT, 50 ppm, but after handling in taking it to the laboratory, only 15 ppm remained. Corn was treated by Dr. L. L. English; residues were determined by Paul Shoffeit, State Toxicology Laboratory.

pounds. In a third experiment, plots dusted with 1 per cent gamma benzene hexachloride at the rate of 20 pounds per acre yielded 1468 pounds of peanuts compared with 1164 on the checks which were not completely defoliated. In a field where dusting was delayed until the plants were over 90 per cent defoliated, the per acre yields of dry peanuts on the various plots at the second digging were as follows: Check, 699 pounds; cryolite, 1232; 1 per cent DDT, 1222; 1 per cent gamma benzene hexachloride, 1032.

Spray-residue studies revealed that DDT persisted on peanut foliage several weeks after dusting. The amount of DDT on peanut hay varied from 2 to 31 ppm. Eight of 13 samples of hay analyzed contained in excess of the 7 ppm tentative tolerance for certain foods. All samples below the tolerance were from fields on which approximately 6 inches of rain fell over the 4- to 5-week period between dusting and harvest.

Livestock fed DDT-dusted hay and unshucked corn for 102 to 143 days stored DDT in the fat and passed it in the milk. The amount stored in the fat varied from 13 ppm in pigs to 160 ppm in steers. A calf suckled by a cow fed DDT-dusted clover hay stored 825 ppm in its fatty tissues. All animals appeared normal. The hay in the feeding experiments contained considerably more DDT than was found on peanut hay under field conditions. —10-5-47.

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CORNELL CONFERENCE ON LIVESTOCK PARASITE CONTROL

A conference on the control of parasites of livestock was scheduled to be held at Cornell University on February 26 and 27. The two-day program has been arranged jointly by the department of Entomology and the school of Veterinary Medicine and members of both departments, along with specialists from elsewhere, appear on the program.

The visiting speakers include Dr. F. C. Bishopp, Dr. E. F. Knipling and Dr. M. P. Jones, of the Bureau of Entomology and Plant Quarantine, Dr. C. D. Lowe and Dr. Frank B. Enzie of the Bureau of Animal Industry, U. S. Department of Agriculture, and Dr. W. E. Swales of the Canadian Department of Agriculture and Dr. Ivan G. Howe, of the New York State Departmentof Agriculture. From the Faculty of Cornell University, Dean W. A. Hagan, Dr. D. W. Baker, Dr. Peter Olafson, Dr. R. R. Birch, Dr. J. A. Whitlock, Mr. Cortland Mapes, Dr. E. N. Moore, of the faculty of the College of Veterinary Medicine at Cornell and Professor H. A. Willman and Professor G. R. Johnson of the Animal Husbandry Department and Dr. J. H. Bruckner of the Poultry Department of Cornell University, as well as Dr. J. D. Sweet, a practicing veterinarian of Chateaugay, New York. Representing the Department of Entomology at Cornell are Dr. C. E. Palm, Dr. H. H. Schwardt, Dr. L. B. Norton, Professor J. G. Matthysse, and Dr. Robert Matheson.

A wide range of topics, especially several which overlap two or more fields of interest, is scheduled for discussion.

Organic Compounds Tested Against Body Louse Eggs[1]

GAINES W. EDDY and N. B. CARSON,[2] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

From 1942 through 1945, 7,068 organic compounds were tested against eggs (nits) of the body louse, *Pediculus humanus corporis* Deg. These materials were classified into four major groups, the most effective group being composed of 312 materials that caused complete mortality of eggs at 1 per cent concentration. During the early research on ovicides all the materials were tested as powders. After a few hundred compounds had been tested by this method, it was discontinued in favor of a solution technique. This paper presents the results obtained with all the materials tested as solutions and with some of the outstanding materials tested as powders.

MATERIALS TESTED AS SOLUTIONS.—*Method.*—The technique used in evaluating the various compounds as ovicides has been described by Bushland *et al.* (1944) and by Eddy (1944). The method is briefly described as follows: Woolen cloth pads, approximately 0.5 inch square, bearing 100 to 200 or more 4 to 6-day-old louse eggs were immersed in alcoholic solutions of the test materials. Lice were removed from the laboratory colony and placed on clean cloth pads every 2 days.

After the pads had been dipped in the test solutions, they were suspended on pins and allowed to dry at room temperature. Usually an hour was sufficient, the time depending on the solvent used. When the eggs were dry they were incubated at 30° C. The relative humidity was kept between 80 and 85 per cent.

The mortality was determined only after hatching was completed in the controls. The examinations were made with a low-power dissecting microscope. Compounds that failed to cause complete mortality (100 per cent) at a particular concentration were not tested at a lower strength. Although not more than 100 eggs were used in each test, only 100 were counted. Usually not more than 2 per cent mortality occurred in the untreated controls.

Ethyl alcohol (95 per cent) was used as the standard solvent. Most of the compounds were soluble in alcohol to the extent of 1 per cent. Materials not soluble in alcohol were dissolved in some other suitable solvent, such as acetone, chloroform, benzene, ether, or water. The results obtained with these solvents tested alone against different ages of eggs are included in this paper.

Results.—Of the 312 compounds that caused complete mortality at 1 per cent strength, 215 were ineffective when they were diluted to 0.5 per cent. These materials are listed below.

Acetic acid, 2-benzoyl-2-methyl-1,3-propanediol diester
Acetic acid, 2-benzyloxyethyl ester
Acetic acid, beta'-butoxy-beta-ethoxyethyl ester
Acetic acid, 3,4-dichlorobenzyl ester
Acetic acid, terpinyl ester
Acetic acid, 2-(2-toloxy)ethyl ester
Acetoacetic acid, benzylethyl ester
alpha-Acetyl-gamma-vinylbutyrolactone
Acrylic acid, beta-benzoylethyl ester
Acrylic acid, beta-benzyloxyethyl ester
Acrylic acid, beta-(beta-*n*-butoxyethyl)ethyl ester
Acrylic acid, beta-(beta-chloroethoxy)ethyl ester
Acrylic acid, alpha-chloropropyl ester
Acrylic acid, cyanoethyl ester
Acrylic acid, beta-(beta-phenoxyethoxy)ethyl ester
Acrylic acid, beta-phenoxyethyl ester
Acrylic acid, tetrahydrofurfuryl ester
Allyl beta-benzyloxyethyl ester
Aminobenzoic acid, ethyl ester
Aminotolyl methyl ether
N-(*n*-Amyl)imide of 1,2-dicarboxy-3,6-endomethylene-4-cyclohexane
o-Amylphenol
N-Amyl-1,2,3,6-tetrahydrophthalimide
Anisaldehyde
p-Anisidine
Anisyl ethyl ether
Anthranilic acid, methyl ester
Azoxybenzene
gamma-Benzal picoline
Benzoic acid
Benzoic acid, allyl ester
Benzoic acid, ammonium salt
Benzoic acid, butyraldehyde oxime ester
Benzoic acid, 2-chloroallyl ester
Benzoic acid, 1,3-propanediol monoester
Benzophenone
1,2-Benzopyrone (coumarin)
Benzothiazole
2-Benzoyl-2-methylpropanediol-1,3
Bromoacetic acid, beta'-butoxy-beta-ethoxyethyl ester
Bromoacetic acid, cyclohexyl ester
2-Bromoethyl 4-chlorophenyl ether
3-Bromo-4-hydroxydiphenyl
beta-Bromophenetole

[1] This work was conducted under a transfer of funds, recommended by the Committee on Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine.

[2] S/Sgt., U.S.A.A.F., assigned from Army Committee on Aerial Dispersal of Insecticides, Orlando, Fla.

beta-Bromopropiophenone
4-Bromo-*o*-toluidine
p-iso-Butoxybenzaldehyde
p-*sec*-Butoxybenzyl alcohol
N-Butylaniline
Butyranilide
Butyric acid, 2-benzoyl-2-methyl-1,3-propanediol diester
Carbonic acid, methyl heptine ester
5-Chloro-*o*-anisidine
4-Chlorobutyrophenone
2-(2-Chloro-4-ethylphenoxy)ethanol
N-beta-Chloroethyl trichloroacetamide
2-Chloro-5-hydroxytoluene
2-(4-Chlorophenoxy)ethanol
3-*p*-Chlorophenoxy-1,2-propane oxide
2-Chloro-4-phenylphenol
4-Chloro-*o*-phenylphenol
Chloropropionic acid, benzyl ester
alpha-Chloropropionic acid, tetrahydrofurfuryl ester
alpha-Chloroquinoline
Cinnamaldehyde
Cinnamic acid, allyl ester
Cinnamyl chloride
Crotonaldehyde 2-benzoyl-2-methyl-1,3-propanediol acetal
Cyclohexanecarboxylic acid
N-Cyclohexyl methalloxyacetamide
o-Cyclohexylphenol
3,4-Dichlorobenzyl methyl ether
Dichlorolevulinic acid, ethyl ester
4,5-Dichloro-3-methylquinoline
2,4-Dichlorophenol
2(2,4-Dichlorophenoxy)ethanol
alpha-*p*-Dichlorophenylacetamide
Dicyclohexyl carbodiimide
p-Diethylaminobenzaldehyde
N,N-Diethyl maleamic (?) acid, ethyl ester
Diglycolic acid, dipropyl ester
9,10-Dihydroacridine
Dihydroeugenol
2,4-Dimethoxyacetophenone
2-(*p*-Dimethylaminophenyl)-4-methyl-1,3-dioxolane
4,4-Dimethyl-2-(*p*-methoxyphenyl)-tetrahydrooxazole
N,N-Dimethyl undecylenamide
2,4-Dinitroanisole
2,4-Dinitrophenyl *n*-propyl ether
Diphenylamine
1,10-Dipiperidinodecane
beta,beta'-Dithiocyanodiethyl ether
p-Ethoxyphenethyl alcohol
2-Ethyl chromone
Eugenol
Formic acid, 1,5-hexanediol diester
o-Formotoluide
Furfural alpha-picoline
Furfurylmethyl *n*-amyl ketone
beta-Furfuryloxypropionitrile
Furylacrylic acid, ethylene glycol ethyl ether ester
Furylacrylic acid, ethyl ester
1-Furylhexene-1-one-3
2-(2-Furyl)-4-methoxymethyl-1,3-dioxolane
1-Furyloctene-1-one-3
1-Furylpentene-1-one-3
Geranic acid (3,7-dimethyloctadiene-2,6-oic acid)
Glycerol monophenyl ether
n-Heptylic acid
Hexahydrobenzoic acid, butyraldehyde oxime ester
Hexahydrobenzoic acid, isobutyraldehyde oxime ester
n-Hexyl diethylene glycol monoether
o-*n*-Hexyloxybenzyl alcohol
o-Hydroxydiphenyl, sodium salt
Hydroxyquinoline sulfate
o-Hydroxyvalerophenone
2-Iodo-2'-phenoxydiethyl ether
Isosafrole
Lactic acid, chloroallyl ester
Lactic acid, beta-chloroallyl ester
N-Loralkyl dibutylamine
Maleic acid, diallyl ester
Maleic acid, di-(methylhydroxyacetyl) ester
Methoxyacetic acid, 1,4-butanediol diester
Methoxyacetic acid, 1,5-pentanediol diester
p-Methoxyacetophenone
p-Methoxybenzyl alcohol
2-(*p*-Methyoxyphenyl)ethanol
p-Methoxyphenylfuryl ketone
1-(4-Methoxyphenyl)-1-propanol
2-(*p*-Methoxyphenyl)-4,4,6-trimethyldioxolane-1,3
4-Methoxypropiophenone
1-Methylbenzothiazole
Methylcinnamyl alcohol
2-Methyl-2-(2-furylvinyl)-1,3-dioxolane
beta-Methylhexanoic acid
alpha-Methylindole (crude)
Methyl maleyl glycolic acid, ethyl ester
3-Methyl-4-methoxyacetophenone
2(*x*-Methylphenoxy)ethanol
Methylphenylaminoacetonitrile
alpha-Methyl-beta-phenylglycidic acid, allyl ester
alpha-Methyl-beta-phenylglycidic acid, ethyl ester
alpha-Methyl-beta-phenylglycidic acid, methallyl ester
alpha-Naphthol
alpha-Naphthylamine
m-Nitroacetophenone
3-Nitro-4-aminotuluene
p-Nitroanisole
o-Nitrobromobenzene
m-Nitrobromobenzene
m-Nitrophenyliodochloride
alpha-Nitroso-beta-naphthol
5-Nitro-*o*-toluidine
1,2-Octanediol
Palmitic acid, 4,6-dinitro-*o*-cresol ester
Pelargonic acid, beta-chloroallyl ester
N,N-Pentamethylene maleamic (?) acid, ethyl ester
p-*n*-Pentoxybenzaldehyde
p-Pentoxybenzyl alcohol
p-iso-Pentoxybenzyl alcohol
o-Phenetidine
Phenoxathiin
Phenoxyacetic acid, 2-ethoxyethyl ester
Phenoxyacetic acid, ethyl ester
1-Phenoxy-3-chloropropanol-2
3-Phenoxy-1,2-propane oxide
x-Phenoxy-*x*-propanol
Phenylacetic acid, beta-chloroallyl ester
alpha-Phenyl-beta-aminopropane (benzedrine)
N-Phenyl butoxyacetamide
Phenyl-*n*-butyl ketone
2-Phenylcyclohexanol
beta-Phenylglycidic acid, ethyl ester
beta-Phenylglycidic acid, methallyl ester
beta-Phenylglycidic acid, methyl ester
Phenyl propiolonitrile
1-Phenyl-2-propoxy ethanol
gamma-Phenylpropyl cyanide
Phenyl *n*-propyl ketone
N-Phenylpyrrole
Phthalide
Piperonal

o-Propenyl *p*-cresol
Propionic acid, *p*-methoxybenzyl ester
p-Propionotoluide
p-Propoxyphenethyl alcohol
x-(*n*-Propoxy)salicylic acid, 2-butoxyethyl ester
p-iso-Propyl benzaldehyde
o-Propyl-*p*-cresol
2-(*p*-*n*-Propylphenyl)ethanol
Pyromucoanilido
Salicylaldoxime
Silicon organic compound, type 500, vis. 10 cstks.
Silicon organic compound, type 500, vis. 20 cstks.
Silicon organic compound, type 500, vis. 5.0 cstks.
Succinic acid, di-2-chlorallyl ester
2,3,4,6-Tetrachlorophenol
1,2,3,4-Tetrahydroquinoline
N,N,-Tetramethylenesuccinamic acid, *n*-propyl ester
p-Thiocresol
Thiocyanic acid, benzyl ester
Thiocyanic acid, beta'-(beta-butoxyethoxy)ethyl ester (80%)
Thiocyanic acid, *n*-decyl ester
Thiocyanic acid, alpha-naphthyl ester
Thiocyanic acid, *n*-octyl ester
Thiocyanic acid, triglycol diester
2-(4-Toloxy)ethanol
beta-(*p*-Toloxy)propionic acid, methyl ester
2,4-Toluenediamine
p-Toluenesulfonic acid, 2-chloroethyl ester
2-(2,4,6-Trichlorophenoxy)ethanol
2,2,4'-Trinitrodiphenylamine
Xylenols, Grade 5-B
2,5-Xylenol

The 97 materials that caused 100 per cent mortality at 0.5 per cent concentration were also tested at 0.25 per cent. At this strength the 77 compounds listed below did not cause complete mortality.

Acetic acid, 4,6-dinitro-*o*-cresyl ester
Acetic acid, 2,4-dinitrophenyl ester
Acetic acid, mercuric salt
Acetylenedicarboxylic acid, diethyl ester
Acrylic acid, beta-bromoethyl ester
Acrylic acid, beta-phenylethyl ester
Allylaniline
p-Aminobenzoic acid, methyl ester
o-Aminodiphenyl
p-Aminodiphenyl
Ammonium dinitro-*o*-cresylate
Anisalacetone
Anisic acid, methyl ester
N'Benzilidene-N,N-dimethyl-*p*-phenylene diamine
Bromoacetic acid, tetrahydrofurfuryl ester
Chloroacetic acid, ethylene glycol diester
Chloroacetic acid, 2-phenoxyethyl ester
alpha-Chloroacetic acid, tetrahydrofurfuryl ester
p-Chlorobenzaldehyde oxime
p-Chlorobenzylcyanide
N-beta-Chloroethylcarbamic acid, beta-chloroethyl ester
Chloromethyl phenyl sulfone
Cinnamic acid, methyl ester
Crotonic acid, 1,3-propanediol diester
4,6-Dibromo-*o*-cresol
3,4-Dichloroacetophenone
2,4-Dichlorobenzylcyanide
3,4-Dichlorobenzylcyanide
3,4-Dichloronitrobenzene
N,N-Diethylfurylacrylamide
Diglycolic acid, diallyl ester (contains hydroquinone)
Dimethyldithiocarbamic acid, methyl ester
m-Dinitrobenzene
2,4-Dinitrochlorobenzene
2,4-Dinitro-*o*-cresol
2,4-Dinitrophenetole
2,4-Dinitrophenol
gamma,gamma'-Dipyridyl
p-Ethoxybenzaldehyde
p-Ethoxypropiophenone
Fumaric acid, dimethyl ester
Furfurylideneacetic acid, ethylene glycol methyl ether ester
Furfurylidene acetone
N-(2-Furfurylidene)-*o*-toluidine
p-Hydroxyphenylpropanol-3
Indole
dl-Malic acid, diallyl ester
p-Methoxyacetophenone oxime
p-Methoxyphenyl *n*-propyl ketone
N-Methyl-*p*-acetotoluidide
Methyl-beta-naphthyl ketone
2-Methylquinoline
6-Methylquinoline
Methyl-*p*-tolyl ketone oxime
beta-Naphthol
2-Naphthonitrile
Nicotyrine
4-Nitro-2-chloroaniline
o-Nitroiodobenzene
p-Nitrophenetole
o-Nitrophenyliodochloride
Pentachlorophenol
Phenylfuryl ketone
Phenylthienyl ketone
Piperonylacetonitrile
2-Pivalyl-1,3-indandione
p-*n*-Propoxybenzaldehyde
p-*n*-Propoxybenzyl alcohol
n-Propylaniline
Quinoline
1,2,3,4-Tetrahydro-2-naphthol
Thioacetanilide
iso-Thiocyanic acid, phenyl ester
N-*p*-Tolylpyromucamide
2,4,6-Trichlorophenol
2-iso-Valeryl-1,3-indandione
Xanthydrol

The compounds that caused complete mortality at 0.25 per cent concentration were also tested at 0.1 per cent. The results are presented below, the figures representing the average mortalities for six tests.

Material	Per Cent Mortality
Chloromethyl *p*-chlorophenyl sulfone (*Lauseto neu*)	100
Sebaconitrile	100
Thiocyanic acid, *p*-dimethylamino phenyl ester	99
Propionic acid, 2,4-dinitrophenyl ester	95
Adipic acid, diallyl ester	94
3,4-Dichlorobenzylcyanide	93
Diazoaminobenzene	90
2-Benzylpyridine	90
Fumaric acid, diallyl ester	89
Difluorodiphenyl disulfide	88

Material	Per Cent Mortality
Hexamethylene bromide	84
Succinic acid, diallyl ester	82
Furfurylideneacetic acid, allyl ester	77
Diphenylamino hydrochloride	67
Toluene sulfonyl fluoride	62
beta-Phenoxypropionic acid, methyl ester	40
p-Methallyloxybenzaldehyde	37
Isoquinoline	32
beta-Bromopropiopic acid, 1,3-propanediol diester	31
beta-Benzoylacrylic acid, methyl ester	23

These 20 materials constitute only about 0.3 per cent of the compounds tested as ovicides. Only two of them—chloromethyl *p*-chlorophenyl sulfone and sebaconitrile—were found to give complete kill of eggs at 0.1 per cent in all six tests. These materials were therefore tested at 0.05 per cent, and the mortalities were 96 and 93 per cent, respectively. Six other compounds caused at least 90 per cent mortality of eggs at 0.1 per cent, but four materials gave less than 40 per cent kill of eggs at the same concentration.

MATERIALS TESTED AS POWDERS.—The materials tested as 0.1 per cent solutions were also tested as powders in pyrophyllite at concentrations of 5, 1, and 0.5 per cent. The higher strengths were chosen, since it was known that most compounds were far more toxic to eggs in solution than in powder form.

The desired amount of the test compound was dissolved in acetone or in some other suitable solvent, and then mixed with pyrophyllite, allowed to dry, and ground to a fine powder on a glass plate. One-half teaspoonful (approximately 1.2 grams) of the powder, along with cloth squares bearing the eggs, was dropped into a paper bag (4-ounce size). The bag was shaken vigorously for about 1 minute. The eggs were then taken out, and the excess powder was removed by a gentle shaking. The eggs were then incubated and tested by the same procedure as that described for materials tested as solutions.

Only six of these materials caused complete mortality at this concentration, although all of them were lethal as 0.25 per cent alcoholic solutions. Sebaconitrile and chloromethyl-*p*-chlorophenyl sulfone, which gave 100 per cent mortality in 0.1 per cent solution, also gave complete kill as 1 per cent powders and 95 and 88 per cent mortality, respectively, as 0.5 per cent powders. Tests with 2,4-dinitrophenyl ester of propionic acid were incomplete owing to the lack of material, but the other two materials were comparatively ineffective.

In general, the compounds which proved the most toxic in alcohol also proved the most toxic in pyrophyllite. However, in some instances the results obtained by the two methods were quite different. Hexamethylene bromide caused practically no mortality as a 5 per cent powder, but 100 per cent mortality as a 0.25 per cent solution in alcohol. No doubt a more thorough and intimate contact of the ovicide is obtained by immersing the eggs in an alcoholic solution of the chemical than by applying the same material in dust form.

TOXICITY OF SOME COMMON SOLVENTS.—Although most of the compounds were soluble in alcohol to the extent of 1 per cent, they were originally tested at

Material	Per Cent Mortality
Sebaconitrile	100
Chloromethyl-*p*-chlorophenyl sulfone	100
2-Benzylpyridine	100
3,4-Dichlorobenzylcyanide	100
Propionic acid, 2,4-dinitrophenyl ester	100
Succinic acid, diallyl ester	100
beta-Bromopropionic acid, 1,3-propandiol diester	99
Adipic acid, diallyl ester	97
Thiocyanic acid, *p*-dimethylaminophenyl ester	96
Difluorodiphenyl disulfide	95
Diphenylamine hydrochloride	92
beta-Phenoxypropionic acid, methyl ester	91
p-Methallyloxybenzaldehyde	84
beta-Benzoylacrylic acid, methyl ester	65
Isoquinoline	62
Diazoaminobenzene	40
Fumaric acid, diallyl ester	33
Toluene sulfonyl fluoride	30
Furfurylideneacetic acid, allyl ester	8
Hexamethylene bromide	3

5 per cent and solvents other than alcohol were necessary. Several materials were found to be suitable, but acetone, benzene, chloroform, ether, and water were the only ones actually used. To determine their suitability as solvents, these materials were tested undiluted against louse eggs in various age groups, 0 to 24 hours, and 1 to 2, 2 to 3, 4 to 5, and 5 to 6 days. None of the materials caused any detectable mortality of eggs.

RESISTANCE OF EGGS OF DIFFERENT AGES.—In the early tests with ovicides

young eggs (0 to 2 days old) appeared less resistant than old eggs (4 to 6 days old). Several hundred compounds were tested against these two age groups, both as solutions and as powders. With few exceptions a greater kill was obtained with young eggs than with old eggs. Eggs held at 30° C. start hatching in the latter part of the seventh day. When eggs 4 to 6 days old are used, the ovicide must kill within approximately 36 hours if hatching is to be prevented, whereas when eggs 0 to 2 days old are used the chemical has about 5 days in which to cause mortality. No difference in mortality between the two age groups was observed when the eggs were dipped in a 2 per cent alcoholic solution of benzocaine and washed in acetone after 10 and 25 minutes and after 1 and 2 hours to remove the benzocaine. Apparently the differences obtained in routine tests were due more to differences in the length of time in which the compounds had to cause mortality than to differences in the resistance of the two age groups.

DISCUSSION.—All the compounds included in this paper caused a greater mortality of eggs at 1 per cent than did undiluted ordinary or deodorized kerosene. Kerosene has been used in the control of pediculosis for many years.

When a material is considered for use as an ovicide against body lice, head lice, *Pediculus humanus humanus* L., or crab lice, *Phthirus pubis* (L.) certain other properties should also be taken into consideration, including its toxicity to man, its ability to remain lethal to motile stages of these insects over a sufficient period, the speed with which it causes immobilization of the lice, and its odor, staining properties, and cost.

All the compounds included in this paper were tested against adult body lice. Aside from 2-pivalyl-1,3-indandione, none of the materials proved to be exceptionally long-lasting pediculicides. Ammonium dinitro-*o*-cresylate, (N-(*n*-amyl) imide of 1,2-dicarboxy-3,6-endomethylene-4-cyclohexene, 2-isovaleryl-1,3-indandione, and chloromethyl *p*-chlorophenylsulfone proved fairly toxic to lice.

Many of the better ovicides were either ineffective against the active stages of the louse or lethal for only a short time after application.

Aside from having ovicidal and long-lasting properties, a material should also cause a rapid knock-down to prevent biting. In the control of most insects a fast-acting material is more desirable than one requiring several hours, or even days, to complete its action. Data on the knock-down effect of most of the compounds mentioned in this paper have already been presented (Eddy & Carson 1946). The six materials that gave complete knock-down of lice in 15 minutes or less were indole; methyl ester of anthranilic acid; 2-isovaleryl-1,3-indandione; 2-pivalyl-1, 3-indandione; beta-(beta-butoxyethoxy) ethyl ester of thiocyanic acid; and *n*-octyl ester of thiocyanic acid. There were also six compounds which caused complete knock-down of lice in 30 minutes, but not in 15 minutes. These were 4-chlorobutyrophenone, beta-chloroquinoline, methyl ester of anisic acid, aminotolyl methyl ether, 4-methoxypropiophenone, and alpha-methylindole (crude). Although none of these fast-acting materials caused complete mortality of eggs at 0.25 per cent, some of those which did kill eggs at this concentration knocked down lice within 1 hour.

TOXICOLOGY.—One of the most important limiting factors in the use of a material in a louse control preparation is its toxicity to man. Many compounds that were found to be highly toxic to the body louse proved too toxic to man to be considered as louse remedies. For instance, 2-pivalyl-1,3-indandione was found to be as effective against lice as DDT and would have been given serious consideration as a possible louse remedy had it been less toxic to man. Most of the liquid compounds and a number of the solid materials listed in the paper have been subjected to pharmacological tests by the United States Food and Drug Administration.

SUMMARY.—From 1942 through 1945 several thousand compounds were tested against the eggs (nits) of the body louse, *Pediculus humanus corporis* Deg. Most of the tests were made by dipping small pieces of cloth bearing 100 to 200 or more 4- to 6-day-old eggs into alcoholic solutions of the test materials, allowing the eggs to dry in the open air for about an hour, and then incubating at 30° C. The relative humidity was held at approximately 85 per cent.

This paper lists the materials that caused complete mortality (100 per cent) of eggs when used at a strength of 1 per cent or less. Of the 312 materials listed, 215 were not lethal at 0.5 per cent. Complete mortality was obtained with 20 compounds at 0.25 per cent, but only 2 of these, chloromethyl *p*-chlorophenyl sulfone and sebaconitrile, proved completely lethal to eggs at 0.1 per cent.

The 20 compounds that caused complete mortality as 0.25 per cent alcoholic solutions were also tested as powders in pyrophyllite. All the materials proved far less effective in pyrophyllite than in alcohol.—10-14-47.

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Tests of the Toxicity to Sheep and Cattle of Certain of the Newer Insecticides[1]

HOWARD WELCH, *Veterinary Research Laboratory, Montana Agricultural Experiment Station, Bozeman*

At the suggestion and with the assistance of J. R. Parker and F. T. Cowan of the Bureau of Entomology and Plant Quarantine Laboratory at Bozeman, Montana, the Veterinary Research Laboratory undertook to determine the toxicity of various insecticides to sheep and cattle. The materials tested were: DDT micronized powder; chlordan, technical grade; benzene hexachloride, 50 per cent wettable powder, 5 per cent gamma isomer; and technical grade methoxy analog of DDT, 1-trichloro-2,2-bis(P-methoxyphenyl) ethane. The latter material was also used as a 50 per cent wettable powder. The tests were conducted during the period from March to July, 1946.

The objectives of the tests were to determine:

1. The maximum safe dose of each insecticide for sheep.
2. The maximum safe dose of each insecticide for cattle.
3. The effect of daily dosages of each insecticide for sheep for 60 days.
4. The effect of grazing sheep on pasture sprayed with chlordan.

MAXIMUM SAFE DOSE FOR SHEEP.—In this experiment the objective was to determine the maximum quantity of the insecticide which could be administered to sheep in one dose without producing toxic symptoms. The DDT, benzene hexachloride and methoxy analog were used as water suspensions. Chlordan was dissolved in an equal quantity of xylene and the solution was emulsified with water by adding a small quantity of emulsifier. All dosages are expressed in grams of the basic technical insecticide. The dosages were administered to the sheep by means of a stomach tube. The doses used in each case started on the basis of 2 grams of the insecticide per kilogram of weight of the sheep followed by smaller doses. The results are shown in table 1.

MAXIMUM SAFE DOSE FOR CATTLE.—The materials administered to cattle were mixed with approximately one gallon of water with a few drops of a wetting agent added to insure better suspension. The cattle were confined in a chute and the material given by a stomach tube. The results are shown in table 2.

The dosages used on cattle were based somewhat on the previous experiments with sheep. The extreme toxicity of chlordan for sheep caused us to set the dose for cattle at an amount obviously below the maximum safe dose. On the other hand, the dose of DDT is plainly too large and the maximum safe dose is somewhat less than 0.5 gram DDT per kilogram body weight.

EFFECT ON SHEEP OF DAILY DOSES

[1] Contribution from the Montana Veterinary Research Laboratory, Montana State College, Agricultural Experiment Station. Paper No. 196 Journal Series.

Table 1.

SHEEP No.	WEIGHT	DOSAGE	GRAMS PER KILO	RESULTS
DDT				
R-5	85	76.5 gm.	2 gm.	Extreme nervousness, muscular jerking, beginning in 24 hours, lasting 5 days. Normal on 9th day.
A-11	97	42.0 gm.	1 gm.	Muscular tremors, incoordination. Normal in 48 hours.
R-11	93	20.0 gm.	.5 gm.	Slight nervous symptoms for 24 hours.
Benzene hexachloride—gamma isomer 10 per cent				
R-36	86	72.9 gm.	2 gm.	Extreme symptoms in 6 hours. Muscular spasms. Practically blind, normal 5th day.
681	124	52.0 gm.	1 gm.	Slight nervous symptoms at 24 hours. Soon normal.
R-12	90	29.0 gm.	.75 mg.	Slight nervous symptoms at 24 hours. Normal at 48 hours.
Chlordan				
R-59	78	65.7 gm.	2 gm.	Severe respiratory and nervous symptoms at 16 hours. Dead at 48 hours.
R-26	123	52.0 gm.	1 gm.	Same as above. Dead at 48 hours.
R-7	103	23.5 gm.	.5 gm.	Incoordination, nervous, partial blindness. Normal 5 to 6 days.
Methoxy analog of DDT				
676	115	48.5 gm.	1 gm.	Remained normal.
R-53	83	70.2 gm.	2 gm.	Remained normal.

FOR 60 DAYS.—Capsules containing 4.5 grams of DDT or its methoxy analog were administered every morning at 8 a.m. to three lots of 2 sheep each. The dosage, 4.5 grams, was selected because it represents the amount of the insecticide on one day's feed for a sheep of forage yielding one ton to the acre, and sprayed at the rate of 5 pounds to the acre, which is a higher rate than has been used for killing grasshoppers. For a 100-pound sheep the dose of 4.5 grams represents 0.1 grams per kilo. Smaller dosages of chlordan and benzene hexachloride were administered to another lot of 2 sheep, the quantity being adjusted to the reaction of the sheep in the tests to determine maximum safe, single dosages.

DDT—Sheep No. 1, weight 107 pounds: Capsules were administered daily for 10 days when severe nervous symptoms developed with twitching lips, jerking head, and general incoordination. The capsule was discontinued for 4 days. Capsule was resumed on the 14th day with recurrence of severe symptoms 20 days later. Capsule administration was dropped for 2 days and resumed with intermittent but less severe symptoms until the 60th day. The weight dropped from the initial 107 pounds to 98 pounds at the 10th day but rose to 104 pounds at the close of the experiment.

Sheep No. 2, weight 86 pounds: Severe toxic symptoms on the 10th day which soon recurred after resuming the capsuling on the 14th day and the sheep was dropped from the experiment with a final weight of 69 pounds.

Chlordan—Sheep No. 3, weight 105 pounds. Sheep No. 4, weight 92 pounds: Each sheep received a capsule containing 3.5 grams of chlordan and 1 gram of xylene at 8:00 a.m. By 5:00 p.m. both sheep were visibly poisoned, showing extreme incoordination, blinking, and jerking of muscles. After a wait of 10 days for symptoms to disappear, the daily capsule was resumed using approximately half the original dosage. On the next day the symptoms recurred and were so pronounced that treatment was again stopped.

Table 2.

AGENT	WEIGHT OF STEER	DOSAGE	GRAMS PER KILO	RESULTS
DDT	540 lbs.	130 gm.	0.5 gm.	Highly nervous, twitching, incoordination. Normal 6th day.
Benzene hexachloride	710 lbs.	42.5 gm.	0.125 gm.	No effect.
Chlordan	820 lbs.	20 gm.	0.05 gm.	No effect.
Methoxy analog of DDT	540 lbs.	130 gm.	0.5 gm.	No effect.

After 5 days a capsule containing 1 gram of the chlordan-xylene mixture was started. After 7 days, sheep No. 3 died suddenly. Postmortem disclosed extensive liver necrosis which may or may not have been caused by chlordan. The 1-gram capsule was continued with sheep No. 4 and on the 15th day the capsule was discontinued for 2 days to allow symptoms to subside. Treatment was resumed and continued until the end of the 60-day period with intermittent recurrence of nervousness. Final weight of the sheep was 85 pounds.

Benzene hexachloride—Sheep No. 5, weight 105 pounds. Sheep No. 6, weight 97 pounds: A capsule containing 2.25 grams of benzene hexachloride was administered to both sheep every morning. After the 20th day both sheep exhibited slight nervousness and incoordination which disappeared and recurred from time to time during the 60-day period. Sheep No. 5 lost 3 pounds and sheep No 6 gained 2 pounds.

Methoxy analog of DDT—Sheep No. 7, weight 100 pounds. Sheep No. 8, weight 100 pounds: Both sheep were given 4.5 grams of methoxy analog daily for 60 days without any change in weight or appearance.

In the above experiments benzene hexachloride produced slight symptoms but no measurable effects from a dosage of 2.25 grams administered daily for 60 days. Methoxy analog administered in daily dosages of 4.5 grams for the same period produced no toxic symptoms.

DDT in a 4.5 gram daily dosage (approximately 0.1 gram per kilo) produced grave symptoms of poisoning after 10 days. These symptoms disappeared after a 4-day rest, and recurred after 20 days more on the same dosage, disappeared after 2 days' rest and only mild symptoms occurred after that.

Orr & Mott (1945) fed sheep on approximately the same dosage of DDT for 3 weeks without visible symptoms of poisoning. However, they fed the DDT only 6 days a week and the 1 day rest may have made a difference. We felt that both sheep would have died if the capsule had been continued past the 10th day when the extreme symptoms first appeared. It was also evident that the sheep acquired a tolerance toward DDT as the symptoms became progressively milder toward the end of the experiment.

Chlordan, in the dosage used, would have undoubtedly killed both sheep had the 4.5 gram dose been continued. The reduced dosage, 1 gram of the chlordan-xylene mixture, or about .018 grams of chlordan per kilo, produced visible symptoms of poisoning at intervals.

EXPERIMENT TO DETERMINE THE TOXICITY OF CHLORDAN-SPRAYED PASTURE TO SHEEP

Lot I One-fifth acre sprayed at the rate of 1 pound chlordan per acre.
Lot II One-fifth acre sprayed at the rate of 4 pounds chlordan per acre.
Lot III One-tenth acre sprayed at the rate of 4 pounds chlordan per acre.

July 13, 8:00 A.M.
Sheep N-1147, weight 113 pounds placed in Lot I.
Sheep HC-1069, weight 125 pounds placed in Lot I.
Sheep H-1069, weight 123 pounds placed in Lot II.
Sheep T-4210, weight 92 pounds placed in Lot II.
July 14, 5:00 A.M. All four sheep appeared to be normal.
8:00 P.M. All four sheep appeared to be normal.

All sheep were observed twice daily until August 4 and remained normal.

July 21
Sheep LK-314, weight 150 pounds placed in Lot III.
Sheep FK-814, weight 128 pounds placed in Lot III.

These sheep remained normal until the close of the experiment on August 4.

SUMMARY.—Six sheep grazed on pasture sprayed with chlordan in amounts equal

to and in excess of the amount used as an insecticide showed no indication of poisoning through a period of 3 weeks immediately following the spraying.

We endeavored to determine the toxicity for sheep and cattle of four insecticides: DDT, chlordan, benzene hexachloride and methoxy analog of DDT.

1. The maximum safe, single dose for sheep appeared to be:
   DDT—somewhat less than .5 grams per kilo.
   Chlordan—considerably less than .5 gram per kilo.
   Benzene hexachloride—somewhat less than .75 grams per kilo.
   Methoxy—produced no toxic effects in the dosage used.
2. The maximum safe, single dose for cattle appeared to be:
   DDT—somewhat less than .5 grams per kilo.
   Chlordan—no toxic effect produced by .05 grams per kilo.
   Benzene hexachloride—no toxic effect produced by .125 grams per kilo.
   Methoxy—no toxic effect produced by .5 grams per kilo.
3. The effects of daily dosages administered in capsules for 60 days were:
   DDT—4.5 grams produced severe symptoms of poisoning at 10 days, which disappeared on discontinuing the dosage for a day or two, reappeared on the 20th day but became less severe toward the end of the experiment.
   Chlordan—a capsule of 4.5 grams of a mixture of chlordan and xylene (3.5 grams chlordan) was extremely toxic and half this dosage proved about as toxic. A dose of 1 gram of chlordan-xylene mixture (.77 grams chlordan) was continued to the end of the experiment producing only mild symptoms. Sheep dosed with capsules containing 2 grams of xylene alone gave no reaction, indicating that the chlordan was the toxic agent.
   Benzene hexachloride—2.25 grams produced only intermittent, mild symptoms.
   Methoxy—4.5 grams produced no symptoms.
4. The effect of grazing sheep on pasture sprayed with chlordan at the rate of 1 pound and 4 pounds per acre:
   Six sheep grazed for 21 days immediately following spraying showed no indication of toxic effect.—10-5-47.

Factors Affecting Tests with DDT Sprays to Control Horn Flies

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The wide variation in the concentrations of DDT recommended for livestock sprays by manufacturers and by research and extension workers has led to considerable confusion. Most of the recommendations are in terms of per cent of DDT in the spray, without consideration of the amount of spray to be applied per animal or of the kind of sprayer to be used.

To obtain information on concentrations of DDT sprays for the control of ectoparasites on livestock, application must be made and results checked by personnel familiar with the life history and habits of the parasites and with all the known factors that may contribute to the success or failure of a spray operation. Furthermore, tests should be made in sufficient replication and under a sufficient variety of conditions that the results may be evaluated properly. More cattle have been sprayed with DDT for the control of the horn fly, *Siphona irritans* (L.), than for any other ectoparasite. Therefore, some of the factors involved in evaluating the results of tests with DDT against this pest may also be applicable to tests against other parasites of livestock.

LIFE HISTORY AND HABITS.—The horn fly is a small biting fly about half the size of the house fly. Unlike other flies attacking cattle, it remains on the animal day and night, except for short periods when it leaves the host to oviposit. It is therefore in constant contact with DDT sprayed on cattle, and a weak spray will eliminate the flies on an animal at the time of treatment and for a short period thereafter.

Oviposition takes place exclusively on fresh cattle droppings, and this is the only natural medium in which the larvae develop. The full-grown larvae pupate in the droppings or in the soil underneath. Therefore, anything that adversely affects the droppings would destroy the potential crops of horn flies. Sometimes a reduction in horn fly populations caused by environmental conditions may be erroneously credited to a DDT spray.

Approximately 99 per cent of the flies emerge from the puparia in the afternoon. Therefore, the time of day that the cattle are checked is also important. It is suggested that the checking be done in the forenoon, since temporary infestations may be observed during the afternoon. Frequently a number of flies have been observed on DDT-sprayed animals in the evening, but all have been killed by the residue before morning. This is especially noticeable 10 days or more after spraying.

Ordinarily the flies congregate on the shoulders and sides of the animals, but in hot sunshine or during rainy weather they collect on the belly. This fact should be taken into consideration when horn fly abundance is being checked, because oftentimes the checking is done from horseback and the under side of the belly cannot be observed carefully.

The average life cycle (egg to adult) of horn flies observed in an insectary during the summer was 9 to 12 days, but in nature it is likely to be about 3 weeks.

METEOROLOGICAL FACTORS.—The time between the spraying and the first rainfall and the intensity and frequency of rainfalls, may have important effects upon the results of a spray test. Heavy rainfall immediately after spraying, and before the cattle are dry, will remove some of the DDT from the animal. Torrential rainfall and flood waters break up or inundate the droppings necessary for horn fly development.

The amount and intensity of sunlight may affect the results of a DDT test. The residual toxicity of DDT is reported to be more lasting when the DDT is protected from sunlight. Therefore, when the effects of DDT sprays are being evaluated the amount of shade available to livestock should be considered. Intense sunlight, together with hot, dry weather, dries out the droppings and thus destroys the breeding medium of horn flies.

PASTURES.—The size and kind of pasture and its proximity to other pastures may also affect the results of a spray test. A small number of cattle in a large pasture often graze over the entire acreage and frequently escape huge numbers of horn flies emerging from droppings in distant parts of the pasture. Large numbers of cattle on a small acreage trample on the droppings, destroying many of the developing horn fly larvae. In pastures containing clover, alfalfa, or other laxative feeds a more liquid dropping is found which is unsuitable for horn fly development. In the Southeast many pastures contain a heavy growth of underbrush, which may rub off appreciable amounts of DDT from the legs, belly, and sides of the animal.

The proximity of heavily infested untreated cattle to the sprayed cattle has an important bearing on the proper evaluation of the duration of the residual toxicity of DDT sprays. Constant exposure of the animals to reinfestation during the tests is desirable so that termination of the residual effectiveness may be indicated by a build-up of horn fly populations Sprays containing enough DDT to persist throughout the life cycle of the horn fly will exterminate a localized infestation, and if the cattle are isolated the horn flies are not likely to build up to nuisance numbers within the year. All stockmen within a given area should spray their cattle at about the same time to reduce the possibility of reinfestation. This community cooperation will result in more lasting horn fly control and reduce the number of sprays that must be applied during the year

BREED, SIZE, AND CONDITION OF CATTLE.—The residual toxicity of DDT sprays appears to be of shorter duration on Brahman cattle than on native or British breeds. The sunlight, their sparse coat of hair, or the secretions from the sweat glands found only in Brahman cattle may be contributing factors. Brahman cattle do not avoid sunlight, whereas other breeds seek the shade The heavier the cost the more DDT will be deposited on the animal; hence it is reasonable to assume longer residual action.

Tests on yearlings and small mature cattle cannot be compared favorably with those on large animals, because fewer horn flies develop in the smaller droppings, and they are more quickly dried out by the sunlight or disintegrated by rainfall. Nor, for the same reason, can tests on cattle with digestive disorders or those on laxative feeds be compared with those on animals not so affected.

UNSPRAYED CATTLE IN TREATED HERD.—In the open range country, especially in the Southeast, it is impossible to round up all the cattle in some herds because of the dense growth of underbrush and the ex-

tensive hammocks. Unsprayed cattle in these woodlands serve as a source of widespread reinfestation, as they seldom "bunch up" and are scattered over a wide area. Therefore, to avoid the prohibitive costs of repeated round-ups, a spray containing enough DDT to give a lasting residual effect is required.

SIZE OF HORN FLY INFESTATIONS.—An abundance of horn flies during the period of the tests is essential if reliable data are to be obtained. In Florida, where our tests were made, the average infestations were from 2000 to 5000 flies per animal.

METHOD OF APPLYING DDT.—The method of application and the type of equipment to use in applying DDT will also influence the results of the tests. These factors are best determined after consideration of the number and kind of cattle to be sprayed, the facilities available for handling cattle, and the type of sprayers available.

On dairy cattle or small herds of gentle beef cattle a DDT suspension may be applied with a sponge over an area of about 1 square foot on each side of the withers, where the flies usually congregate.

Hand sprayers of the nonatomizing type and knapsack sprayers may be used on dairy cattle and small numbers of gentle beef cattle. Since it is difficult to wet an animal thoroughly with sprayers of this type, a maximum residual toxicity cannot be expected. However, excellent results have been obtained, and knapsack sprayers have been used satisfastorily on herds of 400 cattle.

Barrel sprayers are slightly more efficient than knapsack sprayers and are more adaptable to spraying in pens and chutes.

A small power sprayer has proved to be the most practical, and economical means of applying DDT sprays to cattle. This type of sprayer is equipped with a 50-gallon tank, and can be carried in a half-ton pick-up truck or in a small trailer. It will develop a nozzle pressure of about 400 pounds per square inch. An adjustable, long-range orchard spray gun operating under a nozzle pressure of about 300 pounds per square inch, with disk orifices 0.045 to 0.075 inch in diameter, is the most satisfactory. The broom-type nozzles were found to be inconvenient to handle, more wasteful of spray material than the other types, and incapable of spraying at long range.

Large power sprayers have been used but are considered to be too expensive and cumbersome.

Dipping of cattle is still practiced in some localities, but this method is rapidly being supplanted by spraying. The cost of charging a vat with a sufficient amount of DDT to give effective control of ectoparasites is higher than for spraying. However, thorough coverage of cattle with insecticides is obtained by dipping and this method is recommended when eradication of a pest such as the cattle tick is desired.

Spray applications may be made in chutes, pens, or corrals. The most satisfactory method is pen spraying, in which 20 to 40 animals are confined in a small pen, and two operators apply sprays from opposite sides of the pen. Best results are obtained when one operator directs his spray from above, covering the top and sides of an animal, and the other operator directs his spray from below, covering the legs and under sides of the animal. When large pens are used, the spray rig should be placed in the middle of the pen. It is impossible to use broom-type spray guns for this kind of operation. Complete coverage of an animal is not necessary for

Table 1.—Protection from horn flies obtained with various amounts of DDT applied to individual herds.

TESTS	CATTLE SPRAYED	AVERAGE CONCENTRATION OF DDT	DDT PER ANIMAL		PROTECTION TIME[1]	
			Range	Average	Range	Average
Number	*Number*	*Per Cent*	*Grams*	*Grams*	*Days*	*Days*
7	885	0.23	0.71–1.44	1.07	4–21	10.3
8	1924	.45	1.58–2.64	2.15	8–30	21.0
18	2860	.98	3.40–5.80	4.58	14–46	27.5
12	4182	1.45	6.18–8.57	7.05	21–58	35.6
11	3390	2.26	9.07–15.0	11.16	30–60	42.0

[1] Time during which there were less than 25 flies per head.

horn fly control but it gives better results, probably because the DDT on the under side of the animal, being protected from the sun, has a longer residual effect. Furthermore, lice, stable flies, mosquitoes, and other ectoparasites that are usually present can be combated at the same time.

WATER USED IN SPRAYS.—DDT sprays made with soft water seem to have a longer residual toxicity than sprays made with hard water, especially if the latter contains traces of iron. There is no noticeable difference in the initial kill of insects.

CONCENTRATIONS OF DDT AND AMOUNTS APPLIED.—Recommended concentrations of DDT sprays range from 0.2 (Laake 1946) to 2.5 per cent (Stage 1945). Bruce & Blakeslee (1946) showed that a spray containing 2.3 per cent of DDT was more effective than sprays containing 0.23, 0.5, or 1.0 per cent. Howerton (1946) recommends using 0.33 pint per animal; Laake (1946) suggests 2 quarts, and Bruce & Blakeslee (1946) obtained good coverage with 1 to 1.5 pints. The amount of DDT actually deposited on an animal is the only criterion upon which comparative tests can be properly evaluated. Therefore, concentration of a DDT spray must be determined on this basis.

Two questions must be answered—(1) How much spray should be applied to cover the animal thoroughly without appreciable run-off or waste of material, and (2) what is the optimum, or practical, effective concentration of DDT sprays?

In 1945 we sprayed approximately 30,000 cattle. Although accurate records were not kept in all the tests, we did have sufficient records to show that from 1 to 1.5 pints of material was sufficient to spray thoroughly 1 animal. In 1946 we kept accurate records on the amounts of spray material used on 13,241 cattle in 56 tests. The total amount used was 14,837 pints, an average of 1.12 pints per animal. The results of these tests are summarized in table 1, and the relationship between the dose and the period of protection is graphically illustrated in figure 1.

These tests show that an average minimum dose of ¼ ounce of DDT per animal is required to control horn flies for 3 weeks or longer. Slightly higher doses will do no harm and will prolong the residual toxicity. This dose is obtained in 1 pint of a spray containing about 1.5 per cent of DDT. A 1.5 per cent DDT spray can be made by mixing 1 pound of wettable powder containing 50 per cent of DDT with 4 gallons of water. For spraying cattle for the control of horn flies in the Southeast we recommend a suspension containing 1.5 per cent of DDT applied at the rate of 1 to 1.5 pints per animal.

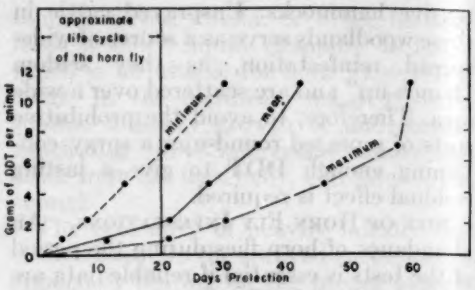

FIG. 1.—Duration of effectiveness of various doses of DDT, as governed by the concentration of the spray, for the control of horn flies on cattle. Florida 1946.

SUMMARY.—Some of the factors involved in evaluating the results of tests with DDT against horn flies, *Siphona irritans* (L.), on cattle are discussed. Tests were conducted to determine (1) how much spray should be applied to an animal to effect thorough coverage, without appreciable run-off or waste of material, and (2) the optimum, or practical, effective concentration of DDT sprays. It was found that approximately 1 pint of spray is sufficient to wet thoroughly an animal of average size, and that a minimum of ¼ ounce of DDT per animal is required for practical horn fly control. One pint of a spray containing 1.5 per cent of DDT contains 7 grams or approximately 0.25 of an ounce of DDT. This amount of DDT will give a residual kill for at least 3 weeks, which is the approximate length of the horn fly's life.

Our recommendation for the control of horn flies on cattle in the Southeast is to apply a suspension containing 1.5 per cent of DDT (made by mixing 1 pound of a 50 per cent DDT powder with 4 gallons of water) at the rate of 1 to 1.5 pints per animal.—11-17-47.

Tests of Materials for the Control of Chiggers on the Ground[1]

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Certain species of *Trombicula* mites have been found to be vectors of *Rickettsia orientalis*, the causative organism of scrub typhus or tsutsugamushi fever. The study of acaricides for the control of chiggers was undertaken at the Orlando, Florida, laboratory of the Bureau of Entomology and Plant Quarantine in 1942 (Madden *et al.* 1944). With the subseqsent development of scrub typhus as a medical problem of major concern in the Western Pacific theater, studies on methods of personal prophylaxis were greatly intensified in 1944, and led to the development of impregnated clothing (Bushland 1946a, b; Snyder & Morton, 1946). During the summer of 1945 about 75 materials were evaluated for the control of chiggers on the ground. The procedures followed and the results obtained are the subject of this report.

Procedure.—Although chiggers are generally distributed in the vicinity of Orlando, areas of high infestation suitable for control studies were difficult to find. Consequently, the smallest possible plot that would give reasonably accurate results was used for preliminary testing. Tests were conducted on sample quadrats 6 feet 7 inches square, having an area of 0.001 acre. In marsh areas and pond-margin types of habitat, where most of these studies were conducted, *Acariscus masoni* Ewg. was the dominant species.

A population index was obtained by means of black filing cards or black pyralin sheets, 5 by 8 inches, set vertically with one edge on the ground. The chiggers came to the cards readily and were conspicuous against the smooth black background. Eight cards were placed at random within a plot and left in position for 1 minute. The chiggers usually concentrated along the upper margin, and when the card was inverted a fairly accurate count could be obtained as the chiggers again moved to the upper edge. The chiggers were returned to the plot after they had been counted. Counts were made before the plots were treated, and on the first, second, fourth, eighth, and twelfth days after treatment.

The number of chiggers on different cards within the same plot was found to be highly variable, but when untreated plots located at random in the test area were checked for several days, the 8-card total count showed a reasonably uniform activity. However, in the untreated area abundance occasionally doubled or decreased by 50 per cent in day-to-day counts. Low counts were recorded on June 1 and 2, coincident with high temperature readings, and a marked decline in activity followed consistent and heavy rains beginning June 21. Throughout the period of testing, counts of 100 to 200 chiggers were ordinarily obtained on the 8-card, 1-minute exposure, and a population in excess of 100 mites per square foot was indicated.

Preliminary Tests.—To determine a dosage suitable for use in screening tests, and also to find a material which might serve as a standard of comparison, a number of preliminary tests were made with several materials which had proved highly toxic in clothing tests—benzyl benzoate, biphenyl, diphenylamine, methyl anthranilate, dimethyl phthalate, and 2-phenylcyclohexanol. These materials were ineffective at dosages equivalent to 4.4 to 22 pounds per acre. Dimethyl phthalate also failed to give adequate control of chiggers at a dosage equivalent to 176 pounds per acre, when applied as a 25 per cent water emulsion. Benzyl benzoate was ineffective at the rate of 44 pounds per acre. Of 21 materials roughly evaluated, the only one of promise was crude benzene hexachloride (gamma-isomer content about 12 per cent). This material gave more than 90 per cent control when applied at rates as low as 4.4 pounds per acre, and was therefore tentatively selected as a standard.

Screening Tests.—Screening studies were then made by applying materials as sprays or as dusts at the rate of 100 pounds of toxicant per acre (approxi-

[1] This work was conducted under a transfer of funds, recommended by the Committee on Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine.

[2] Captain, Sn. C., A.U.S.

[3] Acknowledgment is made of the assistance given by S. R. Pratt in conducting field tests.

Table 1.—Sprays that gave over 75 per cent reduction of chiggers when applied to 1/1000-acre plots at the rate of 100 pounds of toxicant per acre. Materials applied as 33 per cent solutions unless otherwise indicated.

Toxicant	Solvent	Chiggers Before Treatment	Per Cent Reduction on Indicated Days After Treatment				Defoliation
			1	4	8	12	
Benzene hexachloride (about 12% gamma isomer)	Dioxane	218	98	97	99	99	None
		178	95	95	94	89	None
Benzene hexachloride mixtures:							
In dioxane plus an equal volume of a saturated water solution of 2,4-dichlorophenoxyacetic acid	Water emulsion (2% Tween 80)[1]	105	100	98	98	98	Partial
50%+dinitro-*o*-*sec*-butylphenol 50%	Dioxane	543	86	99	99	99	Partial
50%+diphenylamine 50%	Dioxane	261	90	96	99	100	Slight
20%+*Thanite* 80%	Fuel oil	75	99	84	66	81	None
Benzoic acid, benzyl ester (benzyl benzoate)	Kerosene	162	90	81	87	—	None
Coal-tar creosote	Xylene	265	84	85	82	80	Partial
Dinitro-*o*-*sec*-butylphenol	Kerosene	107	93	87	88	92[2]	Complete
Ethylxanthic acid, ethyl ester	Cyclohexanone	62	50	77	84	73	Partial
alpha-Hydroxyisobutyric acid, 2-phenylethyl ester	Cyclohexanone	108	88[3]	—	—	—	Very slight
Nicotine sulfate, 40%	1% in water	215	62	57	80	—	None
Phosphoric acid, tributyl ester (tributyl phosphate)	Cyclohexanone	82	89	90	—	—	Partial
	No. 2 fuel oil	71	99	100	89	93	Extensive
Phosphoric acid, tri-*o*-cresyl ester (tri-*o*-cresyl phosphate)	Cyclohexanone	370	87	85	93	95	Partial
Potassium chlorate	5% in water	382	43	80	69	—	Slight
Salicylic acid, amyl ester	Alcohol	172	0	70	80	84	Partial
Sodium arsenite	Water	219	84	61	55	—	Slight
Sodium bisulfate	Water	97	75	82	38	—	Partial
Sulfur, wettable (commercial product)	50% suspension in water	148	68	61	61	—	None
	Fuel oil	72	94	97	57	65	
2,3,4,6-Tetrachlorophenol	Cyclohexanone	211	40	64	70	—	Slight
Thanite	Kerosene	80	79	89	65	—	Partial
Thialdine	Kerosene	113	88	72	71	—	Partial
1-Trichloro-2,2-bis(p-chlorophenyl) ethane (DDT)	Cyclohexanone	31	74	71	58	—	None
	5% in kerosene (100 gal. per acre)	209	93	93	43	79	Slight
Control (diluent only, at 62 gal. per acre)	Cyclohexanone	108	84	62	18	—	Very slight
	Fuel oil No. 2	62	74	48	37	0	Partial
	Kerosene	79	68	0	46	—	Very slight

[1] Polyoxyalkylene ether of sorbitan monooleate.
[2] 100% after 43 days.
[3] 34% on second day.

mately 1 gram per square foot). Most of the sprays were prepared as 33 per cent solutions in kerosene, cyclohexanone, fuel oil, or other slowly volatilizing solvent, and applied with a small, continuous-flow type of hand sprayer. The dusts, usually 50 per cent mixtures in talc, were applied at first with a small hand duster. Later, however, equally good coverage, with much less loss of material, was obtained by sifting the dusts through a 14-mesh screen colander and then shaking the foliage to distribute the suspended dust on the ground.

With the heavy dosage routinely employed in the screening tests, a treatment that gave a reduction in chigger count of less than 75 per cent was considered ineffective. To be of practical value a material should be effective at less than 50 pounds per acre.

Materials that appeared to have merit as sprays and as dusts are shown in tables 1 and 2. The most effective materials

were tri-*o*-cresyl phosphate, benzyl benzoate, biphenyl, diphenylene oxide, beta-naphthyl ethyl ether, benzophenone, 2,3,4,6-tetrachlorophenol, chloromethyl-*p*-chlorophenyl sulfone, diphenylamine, *Valone* (2-isovaleryl-1,3-indandione), *Thanite* (a mixture of fenchyl and isobornyl thiocyanoacetates), dinitro-*o*-*sec*-butylphenol, pentachlorophenol, tributyl phosphate, and benzene hexachloride. Further work with the materials tested may result in some revision of their relative standings.

Several other materials—iodine, rotenone, naphthalene, 2,6-dimethylnaphthalene, and coumarin—when applied as dusts gave high initial reductions in chigger counts, but the apparent control was not maintained beyond the second day.

Benzene hexachloride, the outstanding compound tested, consistently gave rapid and nearly complete control at 100 pounds of toxicant per acre. Dinitro-*o*-*sec*-butylphenol was highly effective, the plot to which it was applied being completely free of mites 43 days after treatment. Initial kill with the material was 93 per cent, but at the end of a week the kill was only 88 per cent. The later complete elimination of mites may have been due primarily to destruction of the vegetation resulting from its use. It was by far the most effective herbicide of any of the compounds, and the plot to which it was applied showed no sign of plant recovery or regrowth 6 weeks after its application.

In field tests against chiggers in Georgia and South Carolina, Smith & Gouck (1944) obtained good control with sulfur at 57 pounds per acre and with 2 per cent DDT dust at 32 pounds per acre. In the present studies sulfur and DDT were found to be considerably less effective than a number of the other compounds tested. The results with sulfur were variable, but in 18 tests (7 reported in this paper) acceptable control (96 per cent

Table 2.—Dusts which gave over 75 per cent reduction of chiggers when applied to 0.001-acre plots at the rate of 100 pounds of toxicant per acre. Materials mixed with equal parts of talc unless otherwise indicated.

Toxicant	Chiggers Before Treatment	Per Cent Reduction on Indicated Days After Treatment			
		1	4	8	12
Benzene hexachloride	152	99	99	—	—
	65	100	98	97	98
Benzoic acid	88	70	80	80	—
Benzophenone	48	94	88	98	96
Biphenyl	68	94	87	84	54
Chloromethyl-*p*-chlorophenyl sulfone (50 lb. per acre)	77	94	95	94	94
Coumarin	69	84	51	—	—
2,6-Dimethylnaphthalene	142	96	0	—	—
Diphenylamine	76	95	97	99	96
Diphenylene oxide	107	98	100	100	99
Iodine (33% in talc)	145	85	43	—	—
Naphthalene (33% in talc)	232	99	49	74	—
beta-Naphthyl ether (33% in talc)	54	96	94	92	41
Pentachlorophenol	132	78	89	88	96
Phenoxathiin (33% in talc; 60 lb. per acre)	47	83	55	66	—
Rotenone (80 lb. per acre)	154	91	48	—	—
Sulfur, wettable	72	49	58	28	—
	146	70	60	—	—
	240	77	86	89	96[1]
	50	82	92	64	74
Sulfur, wettable (undiluted; 0.1-acre plot)	136	0	36	31	43
2,3,4,6-Tetrachlorophenol	67	97	96	99	97
	90	90	90	59	77
1-Trichloro-2,2-bis(*p*-chlorophenyl)ethane (DDT):					
Undiluted	122	30	14	—	—
10% in talc	72	0	54	0	0
Valone	266	99	93	90[2]	—

[1] 93% on 20th day and 48% on 41st day.
[2] 91% on 48th day.

after 12 days) was obtained in only 1 test (Table 2). One 0.1-acre plot showed less than 50 per cent control to the twelfth day after treatment with sulfur at the rate of 100 pounds per acre. Wettable sulfur applied at the same rate as a 50 per cent suspension in water was ineffective (Table 1). Sulfur in fuel oil gave good control for less than 1 week. DDT, undiluted and as a 10-per cent mixture in talc, failed to give control at this dosage (Table 2). A 5-per cent solution of DDT in kerosene applied at a rate of 100 gallons per acre was effective for 4 days, but a 33-per cent solution in cyclohexanone at 100 pounds of DDT per acre gave less than 75-per cent control in 8 days (Table 1). Cyclohexanone, fuel oil, and kerosene, the diluents most commonly used in the spray formulations, gave approximately 70 to 80 per cent control on the first day when they were used alone.

Materials tested as 33-per cent spray mixtures, at the rate of 100 pounds of toxicant per acre, and which failed to give 75-per cent control by the fourth day were as follows: An aromatic petroleum fraction,[1] chiefly di- and trimethylnaphthalenes, dimethyl phthalate, dibutyl phthalate, pyrethrins (20 per cent pyrethrum extract), an activator composed of pinene, ethylene glycol monoether, alpha-*n*-amylcinnamaldehyde, methyl anthranilate, methyl isobutyl ketone, tetraethylthiuram monosulfide (25 per cent) plus castor oil (25 per cent), 2-phenoxyethyl acetate, diallyl ether, dodecyl mercaptan, a mixture of 1,3-dichloropropylene and 1,2-dichloropropane, trichloropropane, monochlorobutenes, ammonium thiocyanate, and di-isobutyl ketone.

The following materials were ineffective as 50 per cent dusts in talc when tested at the rate of 100 pounds of toxicant per acre: Vanillin, sabadilla seed (powdered), 2,4-dinitro-6-cyclohexylphenol,[1] 2,4-dinitroanisole, pyrethrum powder (2 per cent pyrethrins), cube (ground, 4 per cent rotenone), hexachloroethane, ethyl *p*-aminobenzoate, beta, beta'-dithiocyanodiethyl ether[2] impregnated on a mixture of magnesium carbonate and talc sodium fluosilicate, sodium bisulfite, sodium bisulfate, and ammonium chloride.

TESTS AT REDUCED DOSAGES.—Most of the materials found effective in the screening tests were evaluated further at reduced dosages. The procedures followed were essentially the same as those described for the preliminary tests. An index to chigger populations was obtained before, and at various intervals after, application of dusts or sprays, and control was measured as per cent reduction of chiggers in the treated area as compared with the pre-treatment count. Counts made on six check plots over the period of

[1] *DN Dust.*

[2] *Lethane B-71.*

Table 3.—Tests of selected materials for the control of chiggers in the field, July 18 to August 17, 1945. (Average for 2 tests unless otherwise indicated in parentheses.)

Materials	50 Pounds per Acre					25 Pounds per Acre				
	Chiggers Before Treatment	Reduction on Indicated Days After Treatment				Chiggers Before Treatment	Reduction on Indicated Days After Treatment			
		1	8	12	16		1	8	12	16
		Per Cent					*Per Cent*			
Sprays in kerosene:										
Thanite	100	87	67	54	47	107	89	71	65	64
Tributyl phosphate	72	99	96	93	90	65	74	55	45	34
Tri-*o*-cresyl phosphate	98	90	78	77	73	77	75	78	72	35
Benzyl benzoate	153	82	62	57	52	94	64	32	33	33
Dusts in talc:										
Pentachlorophenol	76	99	90	85	86	79	98	85	89	81
Naphthalene	115	80	55	29	18	118	42	51	63	48
Valone	90	99	94	90	92	86	96	91	86	86
Diphenylene oxide	239	80	80	—	—	229	62	83	—	—
Biphenyl	69	96	0	—	—	88	97	53	—	—
Diphenylamine	117 (3)	84	52	49	45	81 (4)	70	48	51	32
Benzophenone	84	93	58	62	44	86 (4)	91	69	48	23
Benzene hexachloride	119 (6)	99	96	96	96	120	94	96	93	90

the study provided a measure of chigger activity and general population trends. Reasonable uniformity in day-to-day counts was shown.

Materials that gave upwards of 90 per cent control for 1 week or longer when applied to 0.001 acre plots at the rate of 100 pounds per acre were applied to plots of the same size in the form of 25 per cent mixtures in talc or kerosene. Duplicate tests were made of each material at dosages of 25 and 50 pounds of toxicant per acre.

The results of these tests are shown in table 3. Only three materials—pentachlorophenol, *Valone*, and benzene hexachloride—continued to provide a high measure of control at 25 pounds per acre. Tributyl phosphate gave good control at 50 pounds. *Thanite*, biphenyl, and benzophenone gave initially high kills, but none of these maintained a good control beyond the first week after application.

In a series of concurrent tests, biphenyl, diphenylamine, diphenylene oxide, and benzene hexachloride were tested both as dusts in talc and as sprays in cyclohexanone at dosages of 100, 50, and 25 pounds of toxicant per acre. All the materials appeared somewhat more effective when applied as dusts than as sprays. Most of the test area was overgrown with mixed herbaceous vegetation, which may have prevented the sprays from penetrating the foliage and reaching the ground level.

SUMMARY.—Preliminary tests of about 75 selected materials were made to determine their possible value for the control of chiggers in the field. Of these materials 16 gave control of 90 per cent or more when applied as sprays or as dusts to 0.001-acre plots at a rate equivalent to 100 pounds of toxicant per acre. Additional tests of the more promising materials at dosages of 50 and 25 pounds of toxicant per acre showed crude benzene hexachloride to be the most effective. *Valone* (2-iso-valeryl-1,3-indandione) and pentachlorophenol also provided essentially complete control when applied at a dosage equivalent to 25 pounds of pure material per acre. Sulfur and DDT were considerably less effective than a number of the compounds tested.—11-4-47.

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ACTION TAKEN BY COMMITTEE ON COMMON NAMES OF INSECTS

At the 59th annual meeting of the American Association of Economic Entomologists held at Chicago, Illinois, in December 1947, the Committee on Common Names of Insects was authorized to select and adopt, on behalf of the Association, common names for insects and major groups of insects, such as families. On February 11, 1948, a ballot was sent to each member of the committee for action relative to the common names for three insects concerning which an early decision had been requested. As a result of this ballot, the following action has been taken:

Common names adopted	*Scientific names*
oriental fruit fly	*Dacus dorsalis* Hendel
yellow-margined leaf beetle	*Microtheca ochroloma* Stal.
small chestnut weevil (to replace "chestnut weevil")	*Curculio auriger* (Casey)

G. J. HAEUSSLER, *Chairman*

Control of the Cornfield Ant in Golf Greens[1]

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The cornfield ant,[2] *Lasius americanus* Emery, is a serious pest of lawns and golf greens throughout the state of Rhode Island. In general, it is not abundant until mid-July when home owners and greenkeepers become aware of its presence. In the past, several control methods have been suggested, particularly where putting greens were infested. Some of the methods advocated have been found injurious to the turf; some have been moderately successful in controlling the pest, but all have been very time consuming and expensive. The investigations reported here are part of a research program initiated during 1947 to develop new measures for control of various insect and earthworm pests of lawns and golf greens.

MATERIALS AND METHODS—Materials used in the investigations were wettable powders and liquid concentrates containing variable amounts of active ingredient. The wettable powders 50 per cent bis (methoxyphenyl) trichloroethane, benzene hexachloride (6 per cent gamma isomer and 44 per cent other isomers of hexachlorocyclohexane), DDT, 29.3 per cent technical chlorinated camphene, 15 per cent parathion[3] and two commercially available brands of chlordan (containing 50 per cent technical chlordan[4]) here referred to as chlordan (Brand A) and chlordan (Brand B). The latter two materials differed with respect to the source of technical chlordan used and in the nature of the wetting agent employed. They were similar in the type of carrier used and the fineness of grind. Two liquid concentrate formulations were included in the tests; one contained 25 per cent technical DDT (minimum setting point 89° C.), 25 per cent technical chlordan, 47 per cent *Velsicol AR-60*, and 3 per cent special DDT;[5] the other contained 15 per cent technical DDT, 35 per cent technical chlordan, 47 per cent mixed ethers of beta naphthol (60 per cent isobutyl, 20 per cent n-butyl and 20 per cent n-propyl ethers) and 3 per cent special DDT.[5] The materials, formulations and rates of application used in each experiment are given in Tables 1 to 4.

In all tests, plots 5 by 5 feet were used. A rectangular area was selected, large enough to include all materials replicated four or five times; wooden stakes were driven in at the four corners deep enough to escape the blades of the mower, and metal pegs were placed at 5-foot intervals between the wooden stakes. When string was stretched between the metal pegs, the resulting plot layout resembled a gigantic checker board, all squares of which were equal in size and shape. The wooden stakes served as permanent markers to relocate plots after the spray materials had been applied. In laying out plots on golf greens the entire green was always used. The wooden stakes were located on the approaches to the green and the entire green was divided into plots of 25 square feet. Before the sprays were applied, the ant hills in each plot were counted and those plots having few or no hills were not included in the tests. The remaining plots were assigned to the various treatments according to a modified latin square arrangement. After application of the sprays, the metal pegs and string were removed.

Periodic examination of all plots was made by relocation, with the permanent wooden stakes as guides. During each examination the number of ant hills in each plot, as well as notes on phytotoxicity, was recorded. It was arranged that ant control data be taken 2 days after the greens were mowed. All greens used were subject to normal golf play.

The spray materials were applied with a sprayer having a 25-gallon tank and a pump adjusted to deliver 1 gallon per minute at 150 pounds pressure. Uniform coverage of each plot was obtained with a fan-shaped nozzle.

EXPERIMENTAL RESULTS.—The first

[1] Contribution No. 711 from the Rhode Island Agricultural Experiment Station, Kingston, R. I. Paid paper.

[2] Also called the American lawn ant in the East.

[3] O,O-diethyl O-p-nitrophenyl thiophosphate.

[4] According to a statement recently released by the U.S.D.A. technical chlordan is "A commercially produced chemical, containing 60 to 75 per cent chlordan, together with 25 to 40 per cent of related compounds occurring in the normal manufacturing process which are toxic to insects. Chlordan: 1,2,4,5,6,7,8,8-octachloro-4,7-methano-3a,4,7,7a-tetrahydroindane."

[5] Trade name *Emulphor*.

field tests were designed primarily to determine the possible phytocidal properties of the various materials and formulations under consideration. A uniform 3-year-old planting of velvet bent grass turf, located at the Rhode Island Agricultural Experiment Station, was selected for the tests. On June 9, 1947 parathion and all materials listed in table 2 were applied at the rate of 1 pound in 20 gallons of water to 1000 square feet of turf. Daily inspections of the plots were made until June 19, 1947 when a second application, at the above-mentioned rate, was made of all materials except parathion. Daily inspections were continued until June 30, when weekly inspections were instituted for the remainder of the season ending September 29. During the entire period of inspection none of the materials showed phytotoxicity to velvet bent grass. Parathion was discontinued after one application because of its unpleasant odor. The American lawn ant was not abundant on these plots; therefore no data on its control were obtained.

When it became established that the materials under consideration were not toxic to velvet bent grass, a golf green of that grass species, moderately infested with the American lawn ant, was located at Richmond, Rhode Island. On August 6, 1947 the materials listed in table 1 were applied at the rates indicated, and each treatment was replicated four times.

Seven days after the materials were applied, there was a 36.0 per cent increase in ant hills on the check treatment and only chlordan (Brand A) was effective in controlling the American lawn ant. The methoxy analog of DDT had no insecticidal effect since there was an increase of 23.1 per cent in ant hills in plots treated with that material. DDT was found relatively ineffective, for in plots treated with it a reduction of only 8.0 per cent in ant hills was recorded. Neither chlorinated camphene nor benzene hexachloride was particularly effective in controlling the insect for 7 days after treatment the percentage reduction in ant hills for these treatments was 29.7 and 46.4, respectively. The liquid preparation containing 25 per cent DDT and 25 per cent chlordan was somewhat less effective than the wettable powder containing 50 per cent chlordan. Twenty-one days after treatment the percentage of ant hills among the various treatments was found to have changed very little except for the DDT treatment where a reduction of 40.0 per cent was recorded. An examination of the plots 51 days after treatment revealed almost no change in the percentage of hills since the last observation, except that the increase on the check plots was 68.0 per cent as compared with 36.0 per cent previously. Also, an ant hill reduction of 60.7 per cent, compared with 42.9 per cent was recorded for the benzene hexachloride treatment. No in-

Table 1.—Control of the cornfield ant, Richmond, Rhode Island, August 6 to September 26, 1947.

Material	Application Rate per 1000 Sq. Ft.		Ant Hills per 100 Sq. Ft.	Reduction in Ant Hills After:		
				7 Days	21 Days	51 Days
	lb.	*gal.*			*per cent*	
DDT 50% W	1	20	25	8.0	40.0	40.0
Chlorinated camphene 29.3% W	1.7	20	27	29.7	37.0	44.0
Methoxy analog of DDT 50% W	1	20	26	23.1[1]	15.4[1]	15.4[1]
Benzene hexachloride 50% W	1	20	28	46.4	42.9	60.7
Chlordan (Brand A) 50% W	1	20	32	84.4	81.3	87.5
25% DDT 25% Technical chlordan 47% *Velsicol AR-60* 3% Special DDT[2]	1	20	25	60.0	68.0	72.0
Check			25	36.0[1]	36.0[1]	68.0[1]

[1] Denotes increase rather than reduction.
[2] *Emulphor.*

Table 2.—Control of the cornfield ant, West Warwick, Rhode Island, August 8 to September 24, 1947.

Material	Application Rate per 1000 Sq. Ft.		Ant Hills per 125 Sq. Ft.	Reduction in Ant Hills After:			
				7 Days	14 Days	21 Days	47 Days
	lb.	*gal.*		*per cent*			
DDT 50% W	1	20	58	15.5	31.0	34.5	17.2
DDT 50% W	0.5	20	62	25.8[1]	4.8	8.1[1]	4.8
Chlorinated camphene 29.3% W	1.7	20	72	11.1	8.3	2.8	1.4
Methoxy analog of DDT 50% W	1	20	77	2.6[1]	10.4	6.5	3.9[1]
Benzene hexachloride 50% W	1	20	66	50.0	69.7	56.1	54.5
Benzene hexachloride 50% W	0.5	20	70	34.3	60.0	42.9	51.4
Chlordan (Brand A) 50% W	1	20	77	85.7	87.0	77.9	80.5
15% DDT 35% Technical chlordan 47% Mixed ethers beta naphthol 3% Special DDT[2]	1	20	87	67.8	74.7	63.2	56.3
25% DDT 25% Technical chlordan 47% *Velsicol AR-60* 3% Special DDT[1]	1	20	79	55.7	77.2	67.1	77.2
Check			56	35.7[1]	30.4[1]	39.3[1]	39.3[1]

[1] Denotes increase rather than reduction.
[2] *Emulphor* DDT.

jury to the turf resulted from applying the materials shown in table 1.

An experiment similar in many respects to that conducted at Richmond, Rhode Island, was established on a golf course in West Warwick, Rhode Island. On August 8, 1947, the materials indicated in table 2 were applied to a Colonial bent grass green heavily infested with the cornfield ant. Each treatment was replicated five times.

The data in table 2 indicate that after 7 days chlordan (Brand A) was the most effective material for control of the American lawn ant. In general, the data are in agreement with the results of the first experiment: the methoxy analog of DDT, DDT and chlorinated camphene were ineffective in reducing the number of ant hills while benzene hexachloride was moderately effective. Both liquid formulations containing DDT and chlordan were less effective than the wettable powder containing 50 per cent chlordan. Seven days after treatment there was an increase in ant hills amounting to 35.7 per cent in the check treatment. Throughout the remainder of the experiment the number of ant hills in the check treatment remained quite constant, for at 14, 21, and 47 days the increase amounted to 30.4, 39.3, and 39.3 per cent, respectively. None of the materials was toxic to the Colonial bent grass.

On September 3, 1947 two brands of 50 per cent wettable chlordan and a 50 per cent wettable benzene hexachloride were applied to a golf green located at West Warwick, Rhode Island. The green was composed of approximately 40 per cent Colonial bent grass and 60 per cent annual bluegrass and was heavily infested with the cornfield ant. In plots replicated five times, comparable amounts of each material were applied at four dosage levels in 50 gallons of water per 1000 square feet. Water was applied to the check plots at the rate of 50 gallons per 1000 square feet. Data presented in table 3 show that 2, 5, 13, and 26 days after treatment chlordan (Brand B) was much more effective than chlordan (Brand A) in reducing the number of ant hills. When the materials were being applied it was noted that chlordan (Brand A) tended to flocculate badly, particularly at the higher concentrations, when added to water in the spray tank. This may explain the small difference in ant hill reduction when the material was used

Table 3.—Control of the cornfield ant with two brands of chlordan and with benzene hexachloride, West Warwick, Rhode Island, September 3 to 29, 1947.

Material	Application Rate per 1000 Sq. Ft.		Ant Hills per 125 Sq. Ft.	Reduction in Ant Hills After:			
				2 Days	5 Days	13 Days	26 Days
	oz.	*gal.*		*per cent*			
Chlordan (Brand B) 50% W	2	50	64	57.8	42.2	40.6	57.8
	4	50	63	69.8	73.0	61.9	79.4
	8	50	56	82.1	89.3	76.8	91.1
	16	50	60	95.0	95.0	91.7	98.3
Chlordan (Brand A) 50% W	2	50	61	27.9	29.5	23.0	41.0
	4	50	61	55.7	54.1	55.7	78.7
	8	50	71	81.7	71.8	57.7	77.5
	16	50	80	78.8	68.8	80.0	87.5
Benzene hexachloride 50% W	2	50	62	14.5	3.2[1]	8.1	43.5
	4	50	77	27.3	24.7	37.7	41.6
	8	50	51	33.3	15.7	35.3	51.0
	16	50	56	41.1	34.0	55.4	69.6
Water		50	50	32.0[1]	46.0[1]	44.0[1]	16.0[1]

[1] Denotes increase rather than reduction.

at 8 and 16 ounces in 50 gallons of water.

Benzene hexachloride was used for comparison and the data show it was much less effective than chlordan.

Increases of 32.0, 46.0, 44.0, and 16.0 per cent in ant hills on the check treatment 2, 5, 13, and 26 days, respectively, after treatment indicate that ant activity did not reach a peak until sometime between the middle two periods when data were recorded.

A study was conducted on a golf green at West Warwick, Rhode Island, regarding the effect of the amount of water applied with a given amount of wettable chlordan.

The green was composed of approximately 50 per cent Colonial bent grass

Table 4.—The effect of varying the amount of water applied with a 50 per cent wettable chlordan[2] on the control of the cornfield ant, West Warwick, Rhode Island, August 25 to September 24, 1947.

Application Rate per 1000 Sq. Ft.		Ant Hills per 125 Sq. Ft.	Reduction in Ant Hills After:				
			4 Days	9 Days	14 Days	22 Days	30 Days
oz.	*gal.*				*per cent*		
16	25	70	100.0	100.0	98.6	98.6	100.0
16	50	77	98.7	98.7	96.1	96.1	100.0
16	100	68	98.5	98.5	98.5	95.6	100.0
8	25	67	97.0	100.0	97.0	88.1	94.0
8	50	65	95.4	90.8	80.0	84.6	92.3
8	100	88	96.6	94.3	88.6	88.6	94.3
4	25	72	95.8	95.8	81.9	88.9	95.8
4	50	73	91.8	91.8	83.6	74.0	91.8
4	100	76	93.4	94.7	86.8	89.5	94.7
2	25	72	90.3	90.3	63.9	68.1	91.7
2	50	69	88.4	91.3	69.4	60.9	85.5
2	100	78	84.6	82.1	74.4	73.1	76.9
Check		68	4.4[1]	4.4[1]	1.5[1]	7.4	20.6

[1] Denotes increase rather than decrease.
[2] Chlordan Brand B.

and the remainder annual bluegrass, and it was heavily infested with the American lawn ant. On August 25, 1947 chlordan (Brand B) was applied as shown in table 4, each treatment having five replicates. Information relative to the amount of material and water used per 1000 square feet is given table 4. The data indicated that 4 and 9 days after treatment a given amount of a 50 per cent wettable chlordan (Brand B) was more effective when used with 25 rather than with 50 or 100 gallons of water. Fourteen days after treatment the reverse was true at the lower concentrations, for 2 and 4 ounces of the material in 100 gallons of water reduced the ant hills 74.4 and 86.8 per cent respectively, while the same amounts of chlordan in 25 gallons of water brought reductions of 63.9 and 81.9 per cent, respectively. When chlordan was used at 2 and 4 ounces per 1000 square feet, its effectiveness was impaired after 9 days. During the first 14 days of the experiment the number of ant hills in the check treatment remained at the level recorded at the outset, while after 22 and 30 days the reduction amounted to 7.4 and 20.6 per cent respectively. Chlordan (Brand B) was not observed to be phytotoxic to either Colonial bent grass or annual bluegrass.

SUMMARY.—Experiments initiated during 1947 to develop new measures for control of turf pests showed that a 50 per cent wettable chlordan was effective in reducing the ant hill construction activity of the cornfield ant, *Lasius americanus Emery*, on golf greens. Benzene hexachloride was found moderately effective in reducing the activity of the insect, while DDT, chlorinated camphene and methoxy analog of DDT were ineffective. There was wide difference in insecticidal effectiveness between two commercial brands of chlordan containing the same amount of active ingredient. A smaller rather than a larger amount of water, used with a given quantity of a 50 per cent wettable chlordan, was more effective in reducing the number of ant hills in a given area. None of the materials investigated was phytotoxic to velvet bent grass, Colonial bent grass, or annual bluegrass.—12-4-47.

Control of Peach Cat-Facing in Illinois

S. C. CHANDLER[1]

The purpose of this article is to report on the degree of control of peach cat-facing obtained with DDT for two seasons, methods and timing of application, and control of cat-facing obtained with benzene hexachloride and chlordan when applied primarily for plum curculio.

EXPERIMENTS OF 1946.—The principal object of the 1946 tests was to learn what Illinois growers, with a minimum of supervision, could do with DDT, applied at what we considered the proper times, for control of cat-facing.

Drawing on the experience of jarring peach trees over a period of 25 years, each experimental orchard included one standard block in which the first application was made when about 50 per cent of the blossoms were open and the second when shucks were just cracking, being so timed as to hit the peak of tarnished plant bugs and the first appearance of stink bugs. As shown in the tables, variations were made from this standard block, with some blocks receiving only the earlier or the later application. In one orchard a miscible oil containing 5 per cent DDT and 5 per cent benzene hexachloride was applied in the delayed dormant when blossoms were just beginning to open. In all other orchards the material was applied either as a dust or as a spray. The dust contained 5 per cent DDT, 57 per cent sulfur, 5 per cent oil and 33 per cent inert ingredients, and about 8 ounces was applied per tree. The spray contained 1 pound actual DDT wettable powder in 100 gallons and 2 to 4 gallons were applied per tree.

Due to the difficulties of replicating dust plots and in order to increase the chances of securing a sufficiently large

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infestation in the checks, unreplicated tests were conducted in a number of widely separated orchards over southern Illinois. Eight orchards were used, in addition to the one in which the delayed dormant was applied, making in effect a test replicated eight times with a good portion of the peach area as the testing ground. Six growers in four counties, with six different ideas of how to spray or dust, contributed to the practical value of the experiment.

Injury records were made two or more times, once just before thinning, if that were to be done, and once in July a little before harvest. Five hundred peaches were examined each time in each plot and in each variety. The principal variety was Elberta. Records were made by two people.[1] However, so close did the records made by the two people agree—the hundred by hundred figures and the records from the two or more counts and varieties—that they are here combined in table 1, first by individual orchards and second with all orchards combined.

EXPERIMENTS OF 1947.—In 1947, 12 orchards managed by 11 different growers in four peach-growing counties were included in the tests. In nine of the orchards one block only was treated, applying the spray or dust at the two stages as in 1946 (bloom and shuck crack). The adjacent untreated area away from the prevailing winds was used as a check. In the other three orchards, one sprayed and two dusted, an additional block was treated at petal fall making three blocks, one treated at blooming time and shuck split, one at petal fall and shuck split, and one untreated. Because the differences between data taken at successive periods was so slight in 1946, only one set of records was made in 1947. Two and sometimes three people made the records in each orchard. Due to the lower percentage of injury in 1947, a thousand peaches were examined in each block and records kept by hundreds. Table 2 summarizes the data.

Excellent control of curculio in 1947 by use of benzene hexachloride and chlordan raised the hope that applications made primarily for curculio might reduce cat-facing enough that the use of DDT might not be necessary or that the second application might be eliminated.

[1] The detailed report for each orchard is published by Chandler in the Transactions of the Illinois Horticultural Society for 1946.

Table 1.—Summary of data taken on cat-facing from orchards, 1946.

ORCHARD AND TREATMENT	TIME[1]	PEACHES EXAMINED	PER CENT CAT-FACED	PER CENT CONTROL
All Varieties and All Dates of Examination Combined in Each Orchard				
Arnold				
Check		1000	13.9	0
DDT	Delayed	1000	13.4	0
BHC	Dormant	1000	12.2	12.2
Burkey				
Check		3700	17.2	0
2 sprays		1600	2.1	87.7
1 spray	Early	1600	7.0	58.5
McGuire No. 1				
Check		1500	19.7	0
2 dusts		1500	3.5	82.0
1 dust	Early	1500	7.0	64.5
No. 2				
Check		1500	14.2	0
2 dusts		1500	4.5	68.5
Lamer				
Check		900	17.2	0
2 ground dusts		900	2.2	87.1
1 ground dust	Early	900	6.9	70.3
Bilsbrey Two Orchards				
Check		3800	14.6	0
2 sprays		1500	4.5	69.2
1 spray	Early	1500	4.9	66.3
1 spray	Late	1500	6.3	56.7
2 dusts		1300	3.4	77.5
1 dust	Early	1300	5.4	63.0
1 dust	Late	1500	6.9	51.2
Eckert Two Orchards				
Check		2500	15.3	0
2 sprays		1000	1.6	90.5
1 spray	Early	1000	2.4	84.4
2 dusts		3000	2.5	84.3
1 dust	Early	4000	3.4	77.8
1 ground dust	Late	1000	4.6	69.9
2 ground dusts		1000	4.3	72.0
All varieties, all dates of examination, all orchards (except Arnold)				
Check		13900	16.1	0
2 sprays		4100	2.8	82.5
1 spray	Early	4100	5.1	68.5
1 spray	Late	1500	6.3	61.0
2 dusts		7300	3.1	80.9
1 dust	Early	6800	4.6	71.5
1 dust	Late	1500	6.9	57.0
2 ground dusts		1900	3.3	79.5
1 ground dust	Early	900	6.0	62.7
1 ground dust	Late	1000	4.3	73.0

[1] Early and late refer to first and second application.

The normal time to start treatments for plum curculio control in Illinois is when the shucks are pushed one-half to two-thirds off, but due to heavy carry over in four experimental orchards applications were started when shucks were just beginning to crack, or about the time of the second application of DDT for cat-facing. However, a total of at least five applications was made at approximately weekly intervals extending well past the time when cat-facing is normally produced, so that if the materials themselves were effective at that stage in the development

Table 2.—Summary of data on cat-facing from 12 orchards, 1947.

Orchard	Form of DDT	Part Treated	Number of Cat-faced Peaches per Thousand		
			Bloom and Shuck[1]	Petal fall & Shuck[1]	Check, no treatment
McGuire	Dust	Tree	33	59	76
Rendleman	Dust	Tree	13	19	67
H. Heaton	Spray	Tree	58	84	115
Total of three			104	162	258
Per cent reduction			60	37.2	
Meyer	Dust	Tree	21		48
Casper	Dust	Tree	10		50
Keith	Dust	Tree	9		49
Rosson	Dust	Tree	25		42
Metzler	1 Dust	Tree			
	1 Spray	Tree	24		33
Hartline	Dust	Tree	33		67
Hartline	Dust	Ground	26		
F. Heaton					
Orchard 1	Dust	Tree	34		59
Orchard 2	Dust	Tree	24		61
Hale	Dust	Tree	15		39
Grand Total			325		706
Per cent reduction			57.5		
			(13,000 peaches 2.5% cat-faced)		(12,000 peaches 5.8% cat-faced)

[1] Split treatments.

of the peach, a reduction compared with the lead arsenate treated blocks should show in examinations. The materials used and dosages were as follows: (Benzene hexachloride) .9 per cent gamma isomer, oil dust; benzene hexachloride 6 per cent gamma isomer, wettable powder, 2 to 4 pounds per 100 gallons; chlordan 61 per cent, water miscible, 1 pint per 100 gallons; lead arsenate-oil dust, 10 per cent acid lead arsenate or 15 per cent basic lead arsenate; and lead arsenate wettable powder (acid lead arsenate), 3 pounds per 100 gallons. The four orchards in which the tests were conducted were widely separated in four peach growing counties. In mid-June examinations were made of 1000 peaches in each plot. The summary is given in table 3.

Discussion.—Table 1 shows an average reduction of 80 to 82 per cent in cat-facing in 1946 by the application of either two dusts or two sprays when the untreated fruit was 16 per cent injured.

Table 3.—Summary of cat-facing in plots designed for plum curculio control, 1947.

	Number of Cat-faced Peaches per 1000					
Orchard	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Connell	*Lead Dust* 82	*BHC Dust* 107	*Lead Dust* 89	*BHC Spray* 88	*Lead Spray* 91	*Chlordan* 90
Boyd	*BHC Spray* 50	*Lead Dust* 60	*BHC Spray* 67	*BHC Dust* 40		
Springdale	*BHC Dust* 20	*Lead Dust* 42	(*2 trees, check*) 20			
					Plot 4A	Plot 4B
Eisner	*BHC Spray* 36	*Chlordane Spray* 25	*Lead Dust* 33	*BHC Dust* 48	*BHC Dust* 75	

Table 2 shows a reduction of only 57 per cent in 1947. In some way this may be due to the lower general average of cat-facing on untreated fruit which was 5.8 per cent, or a little more than one-third as much as in 1946.

The excellent results obtained in 1946 by either an early or a late application (57 to 71 per cent compared with 80 to 82 per cent for two applications) may possibly be explained by the following three suppositions:

1. Late occurring tarnished plant bugs may cause more injury according to their numbers than the large numbers occurring early, during the blooming period.
2. The residual effect of DDT may have given some protection against the stink bugs which begin to appear about the time of the second application.
3. Stink bugs may have been of greater importance in causing cat-facing in 1946 than tarnished plant bugs.

On the other hand, relatively poor control, 37 per cent, was obtained in 1947 by delaying the first application to petal fall as compared with 58 per cent when the first application was made in the blooming period (Table 2). This may indicate that tarnished plant bugs were more important than stink bugs in 1947. It may also be a partial explanation for the failure of benzene hexachloride and chlordan (Table 3) to give any reduction even though applied several times over a long period beginning when stink bugs first appeared, although the materials themselves may not be as effective as DDT for this purpose.

The failure of a delayed dormant application to give control in 1946 may be due to the comparatively small numbers of tarnished plant bugs occurring at that time. Porter *et al.* (1928) showed the rapid decline in numbers of tarnished plant bugs by the time of petal fall of peach. Chandler (1946) showed the early rise and fall of tarnished plant bugs followed by the increase in stink bugs in the experimental orchards of 1946, and during the intervening years jarring in Illinois has shown that in about 6 years out of 7 the peak occurrence of tarnished plant bugs is well over by petal fall and there are very few left to control.

SUMMARY.—1. Two applications of a 5 per cent DDT oil dust or a spray containing 1 pound of actual DDT in 100 gallons of water applied when 50 per cent of the blossoms were open and again when shucks were just cracking reduced cat-facing on peaches approximately 80 per cent in 1946 and 57 per cent in 1947.

2. Applications made to the leguminous cover crop in the orchard in a limited number of cases gave control approximately equal to that obtained when treatments were applied to the trees.

3. Either the first or the second of these two applications in 1946 gave relatively very good control, but in 1947 even two applications, where the first was delayed until petal fall, gave only about two-thirds as good control as where the first application was made when the peaches were in bloom.

4. DDT applied in the delayed dormant stage in one test gave no appreciable control of cat-facing.

5. Neither benzene hexachloride nor chlordan gave any control of cat-facing in 1947 when applied five or more times beginning with the shuck split stage.—9-12-47.

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Biological Control of Klamath Weed—Progress Report

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In California *Hypericum perforatum* L. is commonly called Klamath weed because it was first reported, about 1900, in northern California in the vicinity of the Klamath River. In Europe, where the weed originates, the common name is St. Johnswort, and according to legend it blooms on June 24, St. John the Baptist's Day. This perennial has a basal growth during the spring and early part of the summer. The erect growth, which flowers and produces seed, may be from 1 to 5 feet tall, depending on local conditions. The plant generally prefers sunny exposures and thrives in well-drained, overgrazed pasture lands where the annual rainfall exceeds 40 inches. The weed is also very aggressive and takes over large areas of open-range grazing lands, greatly depreciating their carrying capacity.

Hypericum perforatum is toxic to sheep and cattle, particularly to cattle. The ingested plant causes white-pigmented portions of the body to become photosensitized. Blisters form on these areas when the animals are exposed to sunlight, resulting in scabby, sore-mouthed, underweight stock.

Chemical control of the weed has had a long and interesting history. In most places the cost of the materials and the inaccessibility of the land to be treated have been limiting factors. Recently the application of borax has been satisfactory in controlling new and small infestations, but this method is impractical in large-scale control programs, because of the cost and other factors.

Biological control by insects has been under consideration for several years as a desirable approach to the problem. The Commonwealth of Australia first began a search for insect enemies of *Hypericum* in 1920 in England, according to a report by Currie & Garthside (1932). Early in 1935, after the British species apparently failed to become established in Australia, the work was transferred to southern France, the results of which are published by Wilson (1943). The preliminary work in Europe consisted of starvation and reproduction tests of a considerable number of insect species on representative plants of economic importance. These tests were made on 42 species of widely distributed plants representing 19 families, to determine whether there was either feeding or reproduction upon them.

After the satisfactory conclusion of the tests in Europe, the species that had shown neither feeding nor reproduction upon the test plants in Europe were exported to Australia. Before liberations could be made, however, it was necessary to make additional tests on plants that did not grow in Europe. The progress of the Australian experiment was followed in California with much interest. About 8 years after releases of two species of *Chrysolina* in Australia, very encouraging results were reported by A. J. Nicholson, in correspondence with Harry S. Smith, of the University of California, College of Agriculture. Negotiations between the University of California and the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, regarding the advisability of introducing the beetles into California resulted in an authorization by the Department to imimport *Chrysolina hyperici* (Forst.), *C. gemellata* (Rossi), and *Agrilus hyperici* Cr., with the proviso that feeding tests be made on the following plants: Sugar beet, flax, hemp, sweet potato, tobacco, and cotton. A cooperative project for the importation, testing, and colonization of these species was then set up between the Bureau of Entmology and Plant Quarantine and the University of California.

Because of the war it was impossible to make collections in Europe. An abundance of material was available in Australia, however, and it could be transported to California by the U. S. Army Air Transport Command. The Australian Council for Scientific and Industrial Research, through Dr. Nicholson, offered to collect and ship the needed material. The collection and preparation of the insects for shipment was under the immediate supervision of T. G. Campbell.

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C. B. Huffaker, of the University of California, has been working on the project since January 1946.

Importations were begun in October 1944. The first problem was to change the life cycles so that they would be in phase with the seasons of the Northern Hemisphere. The specimens of *Agrilus hyperici* were received as mature larvae in roots. Some of them were retarded in cold storage, but others were forced to emerge upon arrival. Neither method proved satisfactory, and further importations were curtailed until the Bureau laboratory in Europe could be reopened.

The two species of *Chrysolina* were occasionally shipped as mature larvae which would emerge as adults upon arrival, feed, and enter aestivation about 3 weeks later. Most of the shipments, however, consisted of aestivating adults. In either event the problem was to bring the adults out of aestivation into the egg-laying phase. By subjecting the adults to fine sprays of water each day, fertile eggs were obtained within 2 to 3 weeks.

In 1944, the first year of importation, sufficient numbers of *Chrysolina hyperici* were received to conduct the feeding tests. The tests were completed in May 1945, with no feeding or egg laying taking place on any of the test plants, and four colonies were released late in the season. One of these became established. The survivors were so few that it was not possible to make recoveries until 1947.

A total of 10,938 adults of *Chrysolina hyperici* were liberated during 1945 and 1946. Of this number, 7438 were imported and 3500 were reared in the insectary. Insectary rearing presents a difficult problem, because there are several generations of common greenhouse pests to one of *C. hyperici*. Small-scale rearing can be handled by transferring larvae to fumigated *Hypericum* plants once or twice during the four instars of larval feeding, but such a procedure is costly and is not suited to an extensive program.

Liberations of *Chrysolina hyperici* have been made in nine different colony sites distributed among five counties in California. Seven of the nine colonies have become established and, already, in two locations complete destruction of Klamath weed can be seen within a radius of 15 yards around the original release locations.

The feeding tests with *Chrysolina gemellata* were completed on January 26, 1946. A total of 13,650 adults of this species were released in one location in each of four counties. The releases were made in February 1946 from imported material that had been received during the preceding two months. All the colonies became established and large increases were noted during the first partial generation. During the second season, 1946–47, two of the colonies did exceptionally well. At the time of their emergence in April and May 1947 the adults could be found readily a quarter of a mile from the point of release.

During the winter the destruction of the basal growth by the larvae was very apparent, and the results of this feeding were evident on new upright spring growth. In the areas of low larval feeding each plant had four or five uprights, whereas in the heavily infested areas the upright growth ranged from none to two small stems. The emerging adults stripped the remaining one or two stems of all their leaves, and an area several yards in diameter is now devoid of any living weed.

Colonization of both *Chrysolina hyperici* and *C. gemellata* has been successful, and the problem now is to obtain more colonies with large yearly increases so that the project will become independent of importations. Distribution to other counties and States will then be undertaken, after which detailed studies can be made of the insects in the various locations and of the ecology of the insect and its plant associations. 11-24-47.

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Insects in Relation to Weed Control[1]

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The most important problems in economic entomology arise from the devastating attacks of insects upon plant life. To agricultural crops these infestations are often the cause of great losses or utter ruin unless adequate control measures are taken to destroy the pests. The control measures inaugurated against these injurious insects constitute a never-ending campaign that continues year after year without apparent prospects for permanent diminution or cessation.

Insects have always been associated with plants. Probably half of the species are plant feeders and are sustained entirely by vegetation while the other half are predaceous and parasitic upon the plant feeders. However, all are dependent upon the vegetable kingdom.

In this discussion only the insects feeding upon plants will be considered.

Geologically speaking, insects are very old—perhaps 50 million or more years. This long association with plants has resulted in many interesting and complicated developments and specializations of both plants and insects. In a great many cases these relationships are beneficial to both groups; so much so that neither could continue to exist alone. In gathering nectar and pollen, insects have become specialized in structure and habits so as to cross pollinate plants whose reproductive powers are wholly dependent upon the food-foraging bees, wasps, flies, beetles, butterflies, moths, and other insects. The extraordinary adaptions of certain moths to pollinate orchids and yuccas are well known examples of the exactness of these relationships. Certain ants collect seeds of plants for food, but in so doing, many seeds are scattered along their trails and about their nests and are thus broadcast.

Insects respond to plants in innumerable different ways. Many are monophagous and can subsist on only a single plant species; others may expand their diet to include a genus of plants, still others have enlarged their quota to a single or several related families, and a great many have become polyphagous and are able to subsist and propagate on a great variety of plants in many widely separated families.

No terrestrial plant is known to be wholly free from insect attack. Many plants like the pines, oaks, willows, poplars, roses, and composites may be the hosts of hundreds and even thousands of species of insects throughout their individual geographical range. The feeding of insects upon certain plants may be a very complicated and specialized process.

There are very many examples of important insect pests that require weeds as hosts and as shelter.

The chinch bug, one of the most serious pests of wheat and corn in the Mississippi, Ohio, and Missouri River Valleys, could not well exist without weeds, grasses, and litter for protection during the severe winters of its habitat.

The green soldier bug, so destructive to ripening peaches in parts of the San Joaquin Valley, California, does not overwinter in clean-cultivated orchards.

Lygus bugs, the most important pests of seeding alfalfa and other seed crops, breed up in great numbers in uncultivated wastelands and continuously migrate into the tilled fields where they destroy the buds and blossoms. They are especially injurious also to beans and cotton.

White grubs, the larvae of June beetles, reproduce extensively on and owe their existence chiefly to wild grasses. They have always been serious pests of wheat, corn, and other grains in extensive grassland areas.

The alfalfa and clover-leaf weevils reproduce abundantly on wild clovers, melilotus, vetches, and other legumes from whence they transfer to alfalfa and clovers.

Cutworms and armyworms breed in tremendous numbers in uncultivated weed and grassland areas and transfer to cultivated crops of all kinds. Their infestations have been greatly lessened by reclaiming these untilled areas for cultivation and by weed control.

Grasshoppers and locusts, the arch-enemies of ancient and modern agriculture, cannot continue to exist in closely grazed or cut grassless and weed-free

[1] Paper presented at the Ninth Annual Western Weed Control Conference, Portland, Oregon. Feb. 6, 1947.

areas. The destruction of the wild hosts in breeding areas could solve the great international problem of locust control.

Aphids and leafhoppers propagate in unbelievable numbers on the numerous wild weed hosts that occur in uncultivated waste lands and in pastures, and along roadsides, ditch banks, fences, and on poorly farmed lands. From the wild hosts they often transmit serious virus diseases to farm crops and ornamentals.

The Colorado potato beetle formerly owed its existence, in parts of North America, to wild solanaceous plants like the buffalo bur from which it transferred to the much preferred potato when the latter became available through the agency of man in the habitat of the beetle.

The various cabbage aphids, bugs, maggots, and worms find natural food supplies in the great fields of wild mustards, radish, and other cruciferous plants. These wild hosts and volunteer garden varieties of the same furnish abundant food for insect propagation during the winter months in temperate and subtropical areas like the Pacific Coast and the southern gulf states.

WEEDS AS RESERVOIRS OF VIRUS DISEASES.—Many weeds and grasses are reservoirs of virus diseases that are transmitted to agricultural crops by insects. The study of plant virus diseases is a relatively new subject, but it has already shown that there are many important and destructive viruses that are extremely injurious to living plants and most difficult to control. One very important method in dealing with these diseases is to destroy the intermediate plant hosts.

It seems very likely that these virus diseases originated in wild hosts and that they have been transmitted to cultivated plants by insects for ages. Fortunately not all insects are able to accomplish this transfer. In fact, only a relatively few groups now appear to be endowed with the capacity to act as intermediaries in taking a virus from one plant and transferring it to another. Certain aphids, leafhoppers, and a few thrips and beetles are capable of making the transfer. These carriers are generally omniverous feeders and capable of carrying the virus to many host plants. The beet leafhopper is the only known insect capable of transmitting curly top virus, whereas the green peach aphid is able to transmit more virus diseases than any known aphid carriers.

In the case of the beet curly top virus, the winter and spring host is chiefly the red-stemmed filaree, *Erodium circutarium*, which grows abundantly on grassy hillsides and plains everywhere in the middle and southern parts of California. The beet leafhopper, *Eutettix tenellus*, overwinters on this plant which is a favored reservoir of the virus. In the spring, the infected leafhoppers migrate to the valleys on both sides of the Coast Range mountains in middle California and continue to feed and breed on the filaree and also on salt bushes, *Atriplex* spp. and other plants. Along the eastern slope of the foothills and the west side of the San Joaquin Valley the leafhoppers gradually work down into the cultivated areas. On the margins of these are great stretches of Russian thistle, *Salsola kali*, which furnishes food for the insects during the late spring and early summer. These plants also become reservoirs of the virus. Thus laden with the disease the leafhoppers migrate to cultivated fields of melons, sugar beets, tomatoes, and other crops and, in feeding, transmit the virus to these plants. In most cases, during years of abundance of leafhoppers, the crops in these infected fields are total losses. Through extensive studies covering a long period of years, it has been discovered that the leafhopper migrations can be greatly retarded and reduced by spraying the weed hosts to destroy the insects as they progress from the hill areas to the cultivated fields. This work has cost the sugar beet growers and refineries thousands of dollars annually and has been remarkably successful. In recent years these repressive measures have been taken over by the state which has extended the control program to the actual destruction of Russian thistle on several thousand acres of grazing land. At the present time the complete extermination of the Russian thistle is being contemplated as a measure likely to prove most practical in reducing future outbreaks of the curly top virus in the San Joaquin Valley.

Investigations in the control of the bean thrips, *Hercothrips fasciatus*, have shown that the destruction of the wild prickly lettuce, *Lactuca scariola*, which is the most important winter host of this insect, adds very greatly to the reduction and the elimination of the thrips as a pest

of field agricultural crops in many sections of California during the succeeding year.

It has also been shown that the elimination of grasses in and around vineyards greatly reduces the numbers of leafhoppers which transmit Pierce's disease of grapevines. Although these leafhoppers do not multiply on the grapevines, yet they do feed sufficiently upon them to transmit the deadly disease which occurs in grasses, alfalfa and other plants growing in and around the vineyards. Here clean culture again appears to be the most effective means of reducing and controlling a virus disease.

It is hardly necessary to pursue this line of argument further to show the great importance of weed control to prevent the great financial losses caused by weeds which act as reservoirs and intermediate hosts of plant virus diseases.

INSECT CONTROL OF WEEDS.—One phase of biological control is concerned with the directed destruction of weeds by insects. This method might prove hazardous if not regulated by state or national authority and if competent men were not in charge. For weed control it is necessary to select only insects that have definite restricted preferences and food habits. Even with these precautions it is always possible that certain insects may change their food habits when introduced into new environments and brought into contact with entirely new and different kinds of plants. The fact that there are so many omnivorous species indicate that untold numbers of insects have gradually widened their dietary routine. The cottony cushion scale in its native Australia appears to have been restricted to the members of the large genera *Acacia, Pittosporum, Casuarina, Grevillea, Hakea,* and possibly other native Australian plants. When introduced into other parts of the world it almost immediately extended its host range to include *Citrus, Rosa, Prunus, Pyrus, Robinia, Vitis, Laurus, Magnolia, Quercus, Buxus,* and many other surprisingly different food plants.

It was introduced into California on *Acacia* and in the very short space of a few years became one of the most serious pests of *Citrus.* Later it appeared in great numbers on other crops including pears and many widely different fruit trees and ornamentals.

Many other examples of the sudden expanding of the host range of introduced insects could be cited.

Because of the dietary changes in insects the greatest care is exercised to employ only the most rigidly restricted species for the control of weeds in new areas. Naturally, if a weed is abundant and over-aggressive in a locality it is assumed that efficient insect enemies do not exist or that they are held in subjection by insect predators and parasites or by other natural checks.

The actual use of insects to destroy weeds or other over-aggressive and destructive plants is relatively recent. Scientists of the Territory of Hawaii, in 1902, began utilizing and distributing the introduced coccid, *Orthezia insignis* Douglas, in an attempt to check the obnoxious *Lantana camara* which had purposely been introduced into the islands as an ornamental and which became a very abundant and severe pest in open grazing lands and in forested areas. In 1902, also, twenty-three different species of insects were introduced into Hawaii to prey upon the lantana plant. The most beneficial insects were those that prevented seed production.

Similar programs of weed control were later adopted against the blackberry, *Rubus fruiticosus;* gorse, *Ulex europaeus;* ragwort, *Senecio jacobaea;* foxglove, *Digitalis purpurea;* and bracken, *Pteris aquilinia,* in New Zealand, and the prickly pear or opuntia cacti, *Opuntia inermis* and *O. stricta,* in Northern Australia. These investigations required the cooperation of botanists, ecologists, agriculturists, and entomologists.

The most recent attempt along these lines are aimed at the control of the Saint John's wort, *Hypericum perforatum* L. This work began in Australia several years ago. A number of insects were introduced from southern Europe. They showed such promise in reducing stands of the weed that steps were taken to establish colonies of the most efficient beetles in California to fight St. John's wort in the Sierra foothills and in Humboldt County. This has been successful and at least one of the chrysomelid leaf-eating beetles has become established and is performing satisfactorily. The ultimate success of this project in California is yet to be ascertained.

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Further Studies of Lures Attractive to the Apple Maggot[1]

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Preliminary studies of bait materials attractive to the apple maggot. *Rhagoletis pomonella* (Walsh), were reported by Benjamin & Hodson (1942) and Hodson (1943). These studies demonstrated the attractiveness of certain chemicals that give off ammonia from aqueous solutions. The most promising of these were glycine, ammonium sulfate, ammonium acetate and household ammonia. These bait materials were tested further and compared with new chemical lures during the summers of 1943 to 47. One of the objects of the investigation was to find a lure that would attract flies at a relatively constant rate for several weeks. In addition, experiments were designed to test the usefulness of traps in fly control, spray timing, and estimation of population numbers.

METHODS.—Before conducting tests of the relative efficiency of different lures, experiments were run to determine the effect of trap position in an apple tree. Three locations were considered: namely, vertical distance from the ground, exposure to sunlight, and proximity to fruit. In these experiments traps containing 1 per cent household ammonia were hung in each of 10 trees. To establish the first point, traps were placed 3 to 4, 8, and 12 feet from the ground. After a 2-week test it was found that the two higher traps caught five or more times as many flies as were trapped at a height of 3 to 4 feet. There was no significant difference between the catches at 8 and 12 feet. These data confirm a similar experiment performed by Boyce & Bartlett (1941). The effect of position with respect to sunlight was tested by hanging traps on opposite sides of each tree. Because convenient branches often were not available in the same locations on each of the trees, the traps varied from south to west on one side and from north to east on the other. Again trap position was found to be important, there being nearly twice as many flies caught on the south-westside as on the north-east side of all but one of the 10 trees. Previous studies, Hodson (1943) showed that traps in non-bearing trees caught comparatively few flies, and the same effect of the presence of fruit was found when catches were compared from traps placed in bearing and non-bearing branches of the same tree.

In most of the comparative tests of lures 10 traps were hung individually near fruit, one on a small tree or two, widely spaced, on the same side of a large tree. These traps were located on the south or west side on the highest branches that could be reached from the ground. They were moved from one tree to another at least three times during each experiment because of the heterogeneous distribution of the fly population. Five-pound honey pails were used as containers for liquid baits, and a small amount of soap or non-soap detergent was added to the baits to insure rapid wetting and immersion of flies attracted to them. Semi-weekly collections of flies were made by pouring liquid baits through a sieve made of galvanized window screening, or by removing captured flies from the sticky surface of dry bait traps with forceps. Water to replace evaporation losses from liquid baits was added when necessary.

LIQUID TRAP EXPERIMENTS.—The liquid lures compared were the following: 1-per cent household ammonia, 2-per cent ammonium acetate, 2-per cent ammonium sulfate, 1-per cent glycine+1-per cent sodium hydroxide, and 2-per cent urea+3-per cent sodium hydroxide. Seven

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experiments were performed for which five orchards were used 1 year, and two a second time the following year. A random distribution of traps in the orchards was obtained by drawing numbers to determine by chance the order in which they should be placed along the tree rows. These experiments were run for periods of three weeks, some simultaneously, and others at different times during the approximately 6-week period of fly emergence.

traps were designed to attract and capture apple maggot flies.

The first dry traps were made from pint size, waxed paper containers, the kind commonly used for frozen fruits and cottage cheese. Ammonium carbonate, a chemical used by Richardson (1916) to attract other Diptera, was employed as the lure. After placing cubes of ammonium carbonate inside, the cover was put in its place, a small pin hole made in it, and the sides of the container smeared with a

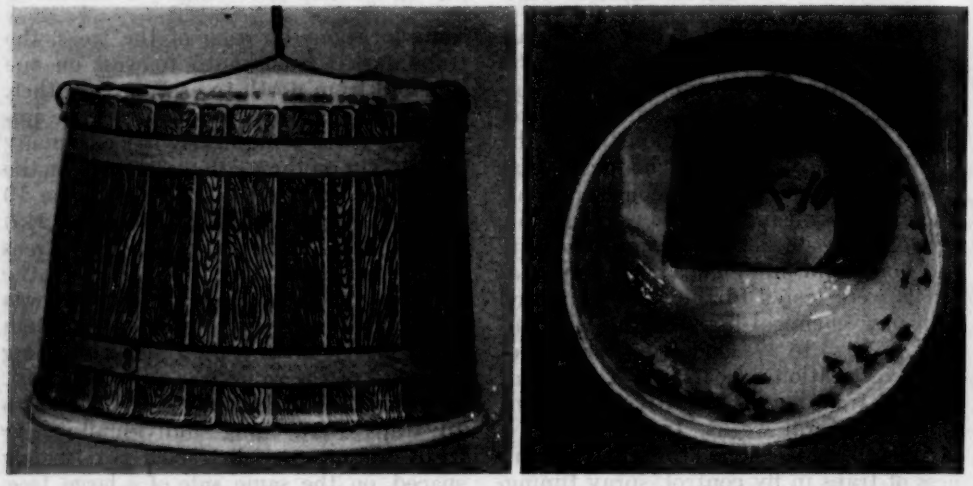

FIG. 1.—(Left). Side view of ammonium carbonate trap as it would be suspended in a tree. (Right) Interior view of same trap showing ammonium carbonate package and flies caught in the sticky surface.

With the exception of the glycine lure there was no significant difference in the attractiveness of the materials, each of them showing the largest catch in at least one of the seven comparative tests. Glycine, on the other hand, was least attractive in all tests.

DEVELOPMENT OF DRY BAIT TRAPS.—Among the several disadvantages of liquid bait traps there are some that commonly make their use unsatisfactory in both experimental and practical work. First among the difficulties is the necessity of straining the flies out of the liquid. Associated with this inconvenience are both discoloration and distortion of the specimens which makes identification difficult for the specialist and often impossible for the untrained observer. In addition, the liquid level must be maintained and liquid-filled pails are often much too heavy to be hung in the most desirable locations. For these reasons dry bait

sticky tree-banding material. Then the assembled trap was suspended by a wire support in an inverted position. Flies were attracted readily to this trap, often darting onto the sticky surface while the trap was being hung in a tree. However, with this design it was difficult to place a trap without having leaves stick to the surface and, furthermore, dry leaves, butterflies, blowflies and dust all reduced trap efficiency. For these reasons, the container was modified, as shown in figure 1, so that the sticky material could be smeared on on the inside wall. The lure was prepared by crushing ammonium carbonate into a coarse powder, about 7 grams being used for each trap. The powdered chemical was placed in a small coin envelope; then the envelope was folded into a rectangular package, wrapped with strips of gummed paper, and the packet stuck to the bottom of the container by pressing it into a pool of melted paraffin.

Two proprietary tree-banding materials were used to catch flies attracted to dry traps, namely, *Tree Tanglefoot* and *Tree Stop*. The latter showed an average 2 to 1 superiority over *Tree Tanglefoot* in four comparative tests. As a consequence *Tree Stop* was used in all subsequent experiments in which the ammonium carbonate lure was used. Another investigator,[1] who has given the dry traps a trial has reported verbally that *Tree Tanglefoot* is not as satisfactory as another banding material called *Deadline*.

Even though the dry trap described above gave a satisfactory performance false bottom traps were constructed by cutting down a cover until it could be forced down to within about 0.25 to 0.5 inch of the bottom of the container. This trap was prepared for use by first placing about 7 grams in the container. Then the false bottom was forced into place, the edges sealed with melted paraffin, the false bottom punctured with a pin, and the inside walls smeared with *Tree Stop*. Three tests were run to compare the efficiency of the packet and false bottom traps. The number of flies caught per trap in these three trials was as follows: Packet traps: 25.2, 25.1, 20.2 and false bottom traps: 26.1, 24.7, 22.9. These trials ran for 4 weeks with no significant difference in the efficiency of the two types of traps. However, laboratory comparisons conducted by measuring weight losses each week for several weeks indicated that the false bottom traps release ammonia at a more constant rate (an average of 0.33 gms. per week) for 3 weeks longer than the packet type. On the other hand, unless a die is used to shape the false bottoms it is not easy to make them uniform in size and with smooth edges.

When ammonium carbonate dry traps were compared with two of the liquid bait materials: household ammonia, and urea plus 3 per cent sodium hydroxide, the results of four tests showed a slight superiority for the two liquid baits. The average number of flies caught per trap by each of them was as follows: Household ammonia, 9.7; urea, 9.0, and ammonium carbonate, 7.5. In another test the liquid urea mixture showed a more marked superiority. In this case two experiments were performed in two widely separated orchards. The average catch per trap for each of them was 55.7 and 91.8 flies in the urea liquid traps, and 21.5 and 20.2 in the dry traps. Dr. C. L. Fluke of Wisconsin also has expressed the opinion that liquid traps caught larger numbers of flies than the dry traps that were sent to him for trial. It cannot be said with certainty whether the apparent lower efficiency of the dry traps as compared with the liquid traps is due more to something associated with the rate of ammonia release or to a smaller percentage of attracted flies being caught on the sticky surface. In spite of their lower efficiency, expressed in total numbers of flies caught, they were equal to any of the liquid lures in attracting the first flies to appear in the orchards.

PERIOD OF ATTRACTIVENESS OF LURES.—While the experiments described above were being run it became apparent that although the initial attractiveness of the lures was much the same there seemed to be larger differences with the passage of time. Because household ammonia seemed to show a marked decrease in attractiveness even after a week of trap operation, a preliminary time test of this material was set up. After 4 weeks of operation 10 traps which were changed weekly caught an average of 29.6 flies per trap. Another group in which the old solution was replaced every 2 weeks caught an average of 14.8 flies; while in still another group that were changed after 3 weeks there was a total catch of only 9.2 flies per trap.

Another, more elaborate, experiment was designed to demonstrate the comparative attractiveness of lures of different ages and composition. In this experiment one set of traps for each of the materials used was made up 3 weeks in advance of the field test. Additional sets of traps were prepared 2 weeks and 1 week in advance. All of these traps were placed in the open with only water added to replace evaporation losses from the liquid bait pails. A set of dry bait traps, of the packet type, were included in the experiment. There are designated in table 1 as ammonium carbonate lures. One week after the last set of traps had been exposed outside, the entire series was hung in a badly infested orchard and allowed to remain in this orchard for 1 week. The lots showing the largest catch plus some new sets were moved to a second

[1] Ray Hutson of Michigan.

orchard and kept in operation for another week. Finally, some of these traps plus three additional lots of new ones were placed in operation for another week in a third orchard. At the end of the experiment the oldest traps had been exposed to the air for 42 days without the addition of more chemical. The results of the experiment are shown in table 1.

Table 1.—A field comparison of the attractiveness of lures of different ages and composition.

	Material	Age of Lure, Days	Average Flies per Trap	S.E.
	Test I			
1	2% Urea+3% Sodium Hydroxide	14	54.6	± 2.4
2	2% Urea+3% Sodium Hydroxide	21	44.2	± 5.7
3	Ammonium Carbonate	7	40.4	± 3.2
4	Ammonium Carbonate	21	39.0	± 3.8
5	Ammonium Carbonate	14	33.8	± 4.1
6	2% Urea+3% Sodium Hydroxide	7	28.6	± 5.9
7	2% Ammonium Acetate	7	21.6	± 4.5
8	2% Ammonium Acetate	14	20.0	± 7.8
9	2% Ammonium Acetate	21	12.8	± 5.9
	Test II			
1	Ammonium Carbonate	28	39.9	± 6.0
2	Ammonium Carbonate	21	39.6	± 7.0
3	Ammonium Carbonate	14	38.2	± 6.4
4	2% Urea+3% Sodium Hydroxide	28	28.0	± 5.5
5	Ammonium Carbonate	7	27.4	± 7.1
	Test III			
1	2% Urea+3% Sodium Hydroxide	35	32.8	± 6.4
2	2% Urea+3% Sodium Hydroxide	7	26.0	± 5.6
3	Ammonium Carbonate	7	19.2	± 4.1
4	2% Ammonium Acetate	7	13.2	± 4.2
5	Ammonium Carbonate	35	2.4	± 5.0

In Test I the age of the lures at the start of the experiment ranged from 1 to 3 weeks. The urea-sodium hydroxide mixture ranked sixth in attractiveness when aged only 1 week, but ranked first and second after longer exposure. In this respect urea-sodium hydroxide in solution behaves like glycine-sodium hydroxide, which increases in attractiveness with age (Boyce & Bartlett 1941) (Hodson 1943). Ammonium carbonate traps of all three ages fell somewhat below the urea-sodium hydroxide lures in attractiveness but showed nearly equal efficiency when compared with each other. Only the bait aged for 2 weeks was significantly different. In this experiment the ammonium acetate lures ranked below the other two and showed a marked decrease in efficiency after aging for 3 weeks before being placed in the orchard.

In Test II the only liquid traps used contained the oldest of the urea-sodium hydroxide mixtures used in the previous experiment. Compared with it were ammonium carbonate traps aged 1, 2, 3 and 4 weeks. The most significant result is the sustained performance of the older materials. The newest dry trap caught the fewest flies, a first week performance common to this material and the urea-sodium hydroxide lure.

In Test III only the oldest of the mixtures used before were transferred to another orchard for the final experiment. As can be seen in table 1 the urea mixture continued to be very attractive and was significantly superior to the lures compared with it. The ammonium-carbonate traps aged for 5 weeks caught very few flies, a result which compares favorably with that obtained in the laboratory when rate of weight loss from these dry traps was studied. While in the laboratory a 2-per cent urea plus 3-per cent sodium hydroxide mixture continued to release ammonia for 13 weeks when measured qualitatively with a phenolphthalein indicator solution. It would seem certain from these results that the urea lure would be most desirable when population emergence rates are being studied.

Another test of the performance of the dry traps over a period of time was carried out coincident to the surveying of apple maggot populations in several orchards. In conducting the survey five traps were placed in each of 10 commercial orchards about 1 week ahead of the first fly emergence. Then, five new traps were hung adjacent to each of the old ones 5 weeks later) 4 weeks after the first flies were caught). The results of the comparison between old and new traps are given in table 2 as the total number of

Table 2.—The attractiveness of ammonium carbonate dry traps after 5 weeks of operation as compared with new traps of the same type.

	Number of Flies per Trap					
	Sixth week		Seventh week		Eighth week	
Orchard	Old	New	Old	New	Old	New
1	5	16	0	2	0	2
2	10	17	2	9	2	0
3	0	2	0	1	0	2
4	0	4	0	4	0	1
5	7	30	1	8	0	2
6	1	5	0	6	0	4
7	4	12	0	3	0	0
8	1	10	1	6	0	2
9	0	1	0	0	1	3
10	5	22	1	4	0	1
Average	3.3	11.9	0.5	4.3	0.3	1.6

flies caught per trap each week for 3 weeks. This experiment again shows that the dry traps lose their attractiveness rapidly after being used in the orchard 4 weeks or longer. In this case the new traps showed at least a 3 to 1 superiority in all except two of the weekly catches made in orchard number 2. As a result of these evaluations of the ammonium carbonate traps in both the field and laboratory it is recommended that old traps should be replaced after 4 to 5 weeks of operation.

APPLICATIONS.—It has not been possible to conduct a conclusive experiment on the use of apple maggot bait traps for control purposes. However, there is some indirect evidence to indicate that they would not be practical, at least on a commercial scale. For instance, it has been shown, Hodson (1943), that flies appear to be attracted over relatively short distances, and further that the presence of fruit seems to be more important in the initial attraction to a tree, or to any particular branch of a tree. Still another bit of evidence, which does not support the use of traps as a means of control, was obtained by taking samples of fruit at harvest time at various distances from single traps hung in several different trees. There was 68 per cent of the fruit clean in samples collected within 3 feet of the traps, while only 21 per cent of the apples were clean 6 to 8 feet away from the traps, and 10 per cent or less at still greater distances.

The operation of traps to determine the approximate date of the first fly emergence is one of the most practical uses both for orchard management and for research purposes. The date of first emergence, as indicated by trap records, compares very favorably with emergence records taken from ground cages. Further evidence is afforded by the fact that the first catch of flies in heavily infested orchards seldom varies more than 2 or 3 days when the orchards are in the same locality. A phenological observation adds some further weight to the contention that the trap records give a fairly reliable indication of the earliest date of emergence. This conclusion is based on a good correlation between the date of the first catch and the average diameter of Wealthy apples measured on that date. Over a period of 5 years the average diameter in centimeters has been 3.9, 3.8, 4.2, 4.1, and 3.8, giving an over all average of 3.9 cm.; while the calendar date varied from July 6 in 1944 and 1946 to July 23 in 1947. This remarkably close agreement between fruit diameter and the first emergence appears to be at least as good as that found for the relationship between time of petal fall and dates of fly emergence from ground cages which has been described by Lathrop & Dirks (1945).

An attempt has been made to determine the value of early trap records for the prediction of the probable infestation at harvest time, and consequently their worth in predicting the need for additional sprays in badly infested orchards. To accomplish this purpose five traps were placed in each of several orchards to obtain a survey record of apple maggot populations. The record is incomplete for the 3-year study because heavy frost damage in both 1945 and 1946 greatly reduced the apple crop, while in 1947 there was an unusually heavy crop but at the same time a very small number of flies in the orchards. In addition to crop failures, the fact that no two orchards were alike with respect to size, varieties planted, tree age, orchard management and proximity to neglected orchards, has made the prediction evaluation of

Table 3.—Relation between trap catches and percentage of fruit infested at harvest time.

Orchard	Average Catch per Trap (Five Traps)		Percentage of Fruit Infested at Harvest	
	First 2 weeks	Total for 1945	Tree run	Drops
1	6.6	66.4	100	100
2	4.8	32.4	98	100
3	1.8	23.8	46	88
4	1.8	16.2	14	52
5	2.8	13.7	28	30
6	1.0	10.2	56	72
7	0.4	6.4	2	10
8	0.0	4.5	10	22
9	0.0	0.6	0	2
		1946		
1	9.6	46.0	100	100
2	1.5	16.5	8	24
3	2.5	6.2	4	24
4	0.2	5.2	8	36
5	0.0	0.8	0	0

trap records very difficult. Nevertheless, the data presented in table 3 give some basis for judgment. It can be concluded from the 1945 records that one or more flies per trap caught during the first 2 weeks of emergence is an indication of a bad infestation, for in each such instance at harvest time there was 10 per cent or more of the fruit damaged on the trees and a much higher infestation of the drops. In one case, orchard number eight, no flies appeared during the first 2 weeks and yet there was commercial damage at harvest time. This can be explained by the fact that there was no fruit in a neglected orchard nearby, a condition which presumably induced a heavy movement of flies to orchard number eight late in the emergence period. Orchard number three suffered a similar invasion, and as a result, shows a higher catch for the entire season than the record for the first 2 weeks would suggest. In 1946 there were several of the orchards included in the survey that had practically no fruit at harvest time as the result of a late spring frost. Even those included in table 3 had very small crops. Still the number of flies caught during the first 2 weeks gives a fair indication of the probable degree of infestation later in the season.

The termination of the apple maggot outbreak in 1947 prevented further exploration of trap uses for research purposes, one of the most promising of which would be the operation of traps in a study of fly dispersal. However, their value in obtaining a record of seasonal numbers at a very low population level was shown in 1947 when a total of only 24 flies was caught in a survey of seven orchards with five traps in each orchard. This figure becomes significant when compared with the record for 1945 which shows a total catch of 332 flies in five traps located in one of the several orchards trapped. It is fair to assume that relative differences in numbers obtained one year as compared with another usually would be significant.

SUMMARY—Several lures composed of aqueous solutions which give off ammonia were compared and found to be nearly equally attractive for short periods of time. One of these, a mixture of 2-per cent urea and 3-per cent sodium hydroxide, was very attractive for several weeks, and the degree of attractiveness seemed to remain relatively constant after the first week of operation. A new type of dry trap was developed which involved the use of ammonium carbonate as the lure. Although the dry traps were somewhat less efficient than the best of the liquid lures, they were superior with respect to the ease with which they could be transported and handled; and the counting of trapped flies was greatly simplified with their use. Some practical uses of apple maggot traps are described and evaluated, particularly their uses for spray timing, damage prediction, and population size estimation.—12-16-47.

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Aerosol Generator Applications of DDT for Codling Moth Control[1]

L. G. Gentner,[2] H. E. Morrison,[3] and W. B. Rasmussen[4]

An experiment was carried on during 1946 in the Medford, Oregon, area to determine the effectiveness of DDT when applied by means of an aerosol generator for the control of codling moth on pear trees. For this purpose a block of medium-size Barlett pear trees was selected in a commercial orchard.[5] The block contained nine rows of 18 trees each, planted 20 feet each way, and covered about an acre and a half of ground.

In 1945 codling moth had been very difficult to control in this block. In 1946 the crop was relatively light, averaging only three or four orchard lugs per tree. This indicated that sufficient codling moth population was available for experimental purposes. The experimental block was bordered on the south by a block of pear trees of similar size, mostly Bartlett, which was used as a check. These trees received the regular number of cryolite sprays (a calyx and five cover sprays) applied by the grower with conventional spray machinery.

The Bartlett variety was chosen because in the Medford area it is the most susceptible to codling moth attack of the five leading pear varieties. The others in the order of susceptibility are Bosc, Comice, Anjou, and Winter Nelis.

Experimental Procedure, Materials Used, and Residue.—DDT applications were made by means of an aerosol generator unit[6] mounted on a four-wheel drive, half-ton truck. The truck was somewhat unwieldy and difficult to maneuver in making turns in the orchard. A stationary boom of four nozzles attached to the generator in a vertical position, one nozzle above the other, was used for applying the materials in the first three treatments. The nozzles were so adjusted that the insecticidal fog enveloped the tree from top to bottom as it was forced toward the tree from one side of the row. A single nozzle with a swivel joint attachment was used for applying the materials in the fourth treatment. This permitted the operator to give direction to the fog.

The principle of this aerosol machine is simple. The unit is equipped with a duplex plunger pump for pumping water and insecticidal materials. Water from a 50-gallon tank is pumped through a series of coils in which it is heated by a flame from a burner. Fuel oil is used in the burner. In this manner superheated steam, varying in temperature from 300° to 900° F. can be generated at a pressure of 100 pounds or more. The temperature is regulated by means of a thermostatic control. At the same time insecticidal materials from another 50-gallon tank are pumped into a nozzle where they are atomized by the steam, producing an insecticidal fog of very small particles. Particle size is apparently dependent upon viscosity of the formulations and upon steam temperature. Data on particle size are limited, but ranges of from 25 microns at 300° F. to 15 microns at 500° have been measured.

Preliminary trials with such materials as DDT, lead arsenate, and cryolite as wettable powders showed that the pump on the generator handled them satisfactorily. However, the resulting deposit was not uniform when the aerosol was forced into the trees from one side. The sides of the leaves toward the nozzle bore a heavy visible residue, while the far sides were often without any visible deposit. These materials settled out rapidly after leaving the nozzle.

It was therefore decided to use DDT in oil solutions for this experiment in codling moth control in order that the material would be carried more uniformly throughout the range of the fog.

The experimental block received a calyx spray of cryolite, applied by the grower, and four applications of DDT

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[5] The use of this block was obtained through the courtesy of Ward Spatz of the Crystal Springs Packing Company, Medford.
[6] Manufactured by the Besler Corporation, Emeryville, California.

Table 1.—Dates of application, materials used, and analyses of residue on fruits.*

Date and Cover	Materials Used	Fruit Sampled	DDT Residue Mic/sq. cm.	DDT Residue ppm
May 21 1st cover	2 lbs. technical DDT 1 gal. xylene 4 gals. oil[1]	After application	11.6	—
June 4 2nd cover	Same as above	After application	6.8	—
June 27 3rd cover	4.5% DDT in oil, visc. 46, U.R. 95[3]	Before application After application	0.9 1.9	— —
July 30 4th cover	2 lbs. technical DDT 1 gal. xylene 1.75 gals. oil[1] 0.50 gal. spreader[4] 1.75 gals. water	Before application Near side[2] Far side After application Near side[2] Far side	1.6 0.3 4.9 2.1	1.7 0.3 5.3 2.3
August 20 Harvest time		Near side Far side	2.1 1.2	2.3 1.3

* Residue analyses on fruit were obtained through the cooperation of R. H. Robinson, Chemist, Oregon Agricultural Experiment Station.
[1] *Deobase* oil used was designated as Standard Base Oil C, with viscosity of 33 seconds Saybolt and U.R. of 95.
[2] Near side and far side are designations to indicate side of tree toward or away from the nozzle, from which samples were collected.
[3] *Shell Residol D.*
[4] *Triton B1956.*

with the aerosol generator, except that the east half of the block did not receive the first aerosol application. The ground was too soft to permit the truck bearing the generator unit to be driven through. The grower later applied a cover spray of cryolite to this portion.

Applications were made by driving down each row and forcing the aerosol through the trees from one side only. The treatments were applied either at night or in the early morning because wind and inversion conditions were more favorable at these times. Even a light breeze caused considerable drifting of the fog.

For the first two aerosol applications the technical DDT was dissolved in xylene and then the oil diluent was added. For the third application a commercial oil containing DDT was used. The last application was in the form of a water-in-oil emulsion. The DDT was dissolved in xylene and oil,[1] the emulsifier was added to the oil, and water was added last. This latter formulation resulted in an improved insecticidal fog. It took approximately 20 minutes to treat an acre and a half of pear trees and about 11 gallons of insecticidal materials were used per application.

Discussion and Results.—At harvest time the fruits from six trees (21 orchard lugs) in the DDT aerosol block were examined for worm injury and also from six trees (24 lugs) in the block bordering the experimental block on the south, which had been sprayed with cryolite. The results are given in table 2.

[1] *Deobase.*

Table 2.—Comparison of codling moth injury at harvest time in blocks sprayed with DDT aerosol and with cryolite.

Treatment	Per Cent Wormy Fruit	Per Cent Stung Fruit	Total Per Cent Injured
DDT aerosol	1.1	0.4	1.5
Cryolite spray	2.4	3.8	6.2

Very satisfactory control of codling moth was obtained from the application of DDT with an aerosol generator in this preliminary experiment, especially in view of the low residue of DDT on the fruit before the third and fourth applications (Table 1). Residue analyses showed a great difference in the amount of DDT on the fruit on the side of the tree toward the nozzle and that away from it.

Codling moth control in the adjoining cryolite block was favorably affected by the drift from the DDT block. On two

occasions the drift was to the south, from the DDT block into the cryolite block. It was interesting to note in scoring the fruit from the latter that the farther removed the trees were from the DDT block, the greater became the severity of injury. The percentage of injured fruit corresponding to the proximity of the tree to the DDT block was 2, 4, 6, and 12 per cent.

Some injury resulted to the fruit and foliage in close proximity to the nozzles from the heavier oil used in the third aerosol application. These parts appeared oily immediately after the treatment.

One limiting factor in connection with this Medford codling moth experiment was the inability to control spider mites. The two-spotted mite, *Tetranychus bimaculatus* Harvey, and the Willamette mite, *T. willamettei* McGregor, predominate in this area and cause serious foliage injury unless controlled. It is necessary to combine an acaricide with some of the regular codling moth applications to obtain this control. Some attempts were made to apply *DN-111* and hydroxy-pentamethyl flavan as wettable powders by means of the generator, but foliage deposits were not satisfactory. Good mite kill was obtained on the portion of the tree nearest the nozzle with the last treatment (DDT water-in-oil emulsion). However, practically no mites were killed on the far side of the tree.

COST STATISTICS.—In table 3 comparison is shown of the cost between aerosol treatments using 5 per cent DDT in solution and applications with conventional spray machinery using 50 per cent wettable DDT.

Table 3.—Comparison of cost between DDT aerosol treatments and applications of DDT with conventional spray machinery.

		AEROSOL GENERATOR	CONVENTIONAL SPRAY MACHINERY
Amount of material used	Per tree	0.5 pt.	10 gals.
	Per acre[1]	6.75 gals.	1080 gals.
Amount actual DDT used	Per tree	0.4 oz.	1.6 ozs.
	Per acre[1]	2.7 lbs.	10.7 lbs.
Time required for treatment	Per tree	7 secs.	3 mins.
	Per acre[1]	12.5 mins.	5.5 hrs.
Total cost per application	Per tree	$0.0567	$ 0.1411
	Per acre[1]	$6.12	15.23

[1] 108 trees per acre.

The above costs include materials, maintenance, and labor. No estimates are given for depreciation. Comparative costs were determined on a basis of 75 cents per gallon for 5 per cent DDT solution and 50 cents per pound for 50 per cent wettable DDT. Labor costs include 85 cents per hour, which was the current wage in the Medford area. It was assumed that two men would be required to operate each type of machine. The over-all saving of 59 per cent in cost is conservative.

SUMMARY.—An experiment was carried on during 1946 in the Medford, Oregon, area to determine the effectiveness of DDT when applied by means of an aerosol generator for the control of codling moth on Bartlett pear trees. The 1.5 acre experimental block received a calxy spray of cryolite, applied by the grower, and four applications of DDT with the aerosol generator. For the first three applications a four-nozzle vertical boom was used and for the fourth a single nozzle with swivel joint. The following formulations were used: first and second applications, 2 pounds technical grade DDT dissolved in 1 gallon xylene and diluted with 4 gallons oil; third application, a commercial oil with a viscosity of 46 seconds Saybolt, containing 4.5 per cent DDT; and fourth application, 2 pounds DDT dissolve in xylene and oil, and emulsified. The insecticidal fog was forced into the trees from one side of each row only. DDT residue on the fruit was much greater on the side of the tree nearest the nozzle than on the far side. Very satisfactory control of codling moth was obtained. The addition of a suitable acaricide to DDT in some of the codling moth applications is necessary to control spider mites, which cause serious injury to pear trees. Preliminary tests with *DN-111* and hydroxy-penthamethyl flavan as wettable powders were unsuccessful. DDT in solution can be applied by means of the aerosol generator at a saving of at least 59 per cent as compared with the application of DDT 50 per cent wettable powder by means of conventional spray machinery.—7-11-47.

Criteria of Effect Used in Determining Codling Moth Injury[1]

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In evaluating damage by codling moth larvae, *Carpocapsa pomonella* (L.), several criteria have been employed, but, at present, no uniformity of usage exists. The desirability of increasing information on this subject became apparent in 1939 when field experiments at Mitchellville, Iowa, were in progress. Investigations of the suitability of several criteria were undertaken in that year, and were continued in 1940. These investigations were concerned with the relationship between (1) the number of injuries and the number of injured fruit, and (2) between the number of worms and the number of wormy fruit in the sampled apples. Comparisons were also made among wormy fruit, stung fruit, injured fruit, worms, stings, and injuries. Another comparison involved the ratios of worms to stings. The practical control aspects of these investigations have already been published in two papers (Graham & Richardson, 1940, 1942), to which the reader is referred for details of plot arrangement, and of treatments and their outcome.

EXPERIMENTAL DESIGN.—In 1939 the plots were laid out in a commercial apple orchard and were divided into two sections. All the trees of one section were of the Delicious variety, were 23 years old and were fairly uniform in size and crop. This section is hereinafter called the Delicious Section. The other section contained several varieties of trees, but mostly of the Jonathan variety, from 20 to 35 years old, of various sizes and with variable crops. Hereinafter this section will be known as the Jonathan Section. Each section contained 4 blocks of 4 randomly placed single row plots. Four spray treatments were applied to the experimental blocks: (1) calcium arsenate and soybean flour; (2) lead arsenate; (3) calcium arsenate; (4) lead arsenate and soybean flour. Prior to harvest, 40 apples from 6 trees of each plot were picked and cut open to determine the different types of codling moth injury. Records were taken of the number of injured fruit, worms, stings and injuries (worms+stings) (Tables 1 and 2).

Table 1.—Results of damage in 1939 by codling moth larvae in the Delicious Section. Data were taken on September 19, 1939 preceding the harvest. Each figure in this table is derived from 24 samples of 40 apples each.

TREATMENT	PER CENTAGE OF INJURED FRUIT	PER 100 APPLES NUMBER OF:		
		Worms	Stings	Injuries
Lead Arsenate	15.9	19.1	7.4	26.5
Lead Arsenate and Soybean Flour	16.6	18.4	7.0	25.4
Calcium Arsenate	20.7	28.2	5.1	33.3
Calcium Arsenate and Soybean Flour	21.9	32.5	7.4	39.9

Table 2.—Results of damage in 1939 by codling moth larvae in the Jonathan Section. Data were taken on September 19, 1939 preceding the harvest. Each figure in this table is derived from 24 samples of 40 apples each.

TREATMENT	PERCENTAGE OF INJURED FRUIT	Per 100 APPLES NUMBER OF:		
		Worms	Stings	Injuries
Lead Arsenate	27.3	32.8	12.9	45.7
Lead Arsenate and Soybean Flour	21.7	21.4	12.7	34.1
Calcium Arsenate	34.9	42.3	13.4	55.7
Calcium Arsenate and Soybean Flour	33.0	44.8	9.7	54.5

In 1940 the experimental design was the same but the 4 treatments consisted of: (1) lead arsenate, hydrated lime, soybean flour; (2) lead arsenate, hydrated lime, a proprietary spreader-sticker; (3) lead arsenate, hydrated lime, lime casein; (4) lead arsenate, hydrated lime. Only apples from the Delicious Section were cut open for intensity studies because of the greater uniformity of the infestation in this Section. Twenty-five apples picked from each of 4 trees of each plot were examined for wormy fruit, stung fruit, injured fruit, worms, stings and injuries (worms+stings) (Table 3).

RELATIONSHIP BETWEEN CRITERIA.—As a codling moth infestation increases, the number of injuries and the number of worms increase in a different ratio from the number of injured fruit and the num-

[1] Journal Paper No. J-609 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 389. This work was done under the direction of Charles H. Richardson, project leader.

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Table 3.—Results of damage by codling moth larvae in 1940. Data were taken on October 8, 1940 preceding the harvest. Each figure in this table is derived from 16 samples of 25 apples each.

TREATMENT	PERCENTAGE OF:			PER 100 APPLES NUMBER OF:		
	Damaged Fruit	Wormy Fruit	Stung Fruit with No Worms	Worms	Stings	Injuries
Lead Arsenate	87.5	31.8	55.8	70.2	344.8	415.0
Lead Arsenate and Soybean Flour	89.0	33.2	55.8	73.8	382.2	456.0
Lead Arsenate and Lime-Casein	89.5	28.2	61.2	56.2	305.2	361.5
Lead Arsenate and Proprietary Spreader-Sticker	85.0	20.5	64.5	39.8	348.5	388.2

ber of wormy fruit respectively. All of them tend to increase in geometric progression. The regression of one variable upon another both of which increase in a geometric progression is fitted by the following equation:

$$Y = aX^b.$$

This equation in logarithmic form can be written as:

$$\log Y = \log a + b \log X.$$

A form of the general linear regression equation as given by Snedecor (1946) is:

$$\hat{Y} = a + bX.$$

It also occurs in this form:

$$\hat{Y} = \bar{y} + \frac{Sxy}{Sx^2}(X - \bar{x})$$

where

$\hat{Y}$ = predicted Y
$\bar{y}$ = mean of Y
$\bar{x}$ = mean of X
Sx^2 = Sum of squares of deviations from the $\bar{x}$
Sxy = Sum of cross products of respective deviations from the means $\bar{y}$ and $\bar{x}$

This equation can be converted into the following:

$$\widehat{\text{Log } Y} = \log y + \frac{S(\log x)(\log y)}{S(\log x)^2}(\text{Log } X - \overline{\log x})$$

with similar interpretations of terms. For the regression of the number of injuries per injured fruit from the 1939 data the following equation is obtained:

$$\widehat{\text{Log } Y} = 1.1052 + \frac{14.775195}{14.861823}(\text{Log } X - 0.9189)$$

$$\widehat{\text{Log } Y} = 0.1916 + 0.9942 \text{ Log } X$$

$$Y = 1.555X^{0.9942}.$$

From the 1940 data the number of injuries per injured fruit is expressed by the equation:

$$Y = 0.0105X^{2.9492}$$

which was derived in the same manner as the one immediately preceding it. From the 1940 data the number of worms per wormy fruit is expressed by:

$$Y = 1.112X^{1.2694}.$$

For the equation of the number of worms per 100 apples based on percentage of wormy apples Hansberry[1] obtained the following:

$$Y = 1.049X^{1.1096}$$

from data taken at Wenatchee, Washington in 1932 and 1933. These equations show the relationship between certain criteria and are useful in converting data from one criterion to another. They differ with respect to locality and season which must be considered when they are employed.

DISCUSSION.—The analysis of variance of the 1939 data of the Delicious Section is shown in table 5. The value of F for treatment is greatest when the number of worms is taken as the criterion of effect. This is considered to be a more sensitive test than any of the others as a higher value of F indicates a greater sensitivity.

[1] Unpublished thesis, Iowa State College, 1936.

Table 4.—Data compared on the basis of the ratio of worms to stings.

TREATMENT	MEAN OF RATIOS	RATIO OF TOTALS
1939 Jonathan Section Lead Arsenate	2.618	2.540
Lead Arsenate and Soybean Flour	2.156	1.680
Calcium Arsenate	3.669	3.147
Calcium Arsenate and Soybean Flour	4.682	4.624
1939 Delicious Section Lead Arsenate	2.586	2.577
Lead Arsenate and Soybean Flour	2.667	2.642
Calcium Arsenate	6.876	5.531
Calcium Arsenate and Soybean Flour	5.286	4.394
1940 Delicious Section Lead Arsenate	0.2144	0.2038
Lead Arsenate and Soybean Flour	0.2053	0.1929
Lead Arsenate and Lime-Casein	0.1888	0.1843
Lead Arsenate and Proprietary Spreader-Sticker	0.1167	0.1141

The number of injuries gives a more sensitive test than the number of injured fruit. The F value for injuries is greater than the value of F at $P=0.05$ while F for injured fruit is lower. Although the value of F for injured fruit is below the value for significance it approaches significance and cannot be cast aside without consideration. No differences occur with stings indicating that stings do not contribute to the variation between treatments. In comparing calcium arsenate directly with lead arsenate (Table 5, calcium arsenate vs. lead arsenate) the order of the sensitivity of the tests is the same as that based on the value of F.

The 1939 data of the Jonathan Section are analyzed in table 6. This analysis is not considered to be equal to the analysis of table 5 owing to the greater variation in trees of the Jonathan Section. This table is inserted to augment the data analyzed in table 4. A consideration of the F values of the various treatments of table 6 indicates that the criterion, worms, gave the most sensitive analysis followed by that of injured fruit and of injuries respectively When calcium arsenate is compared with lead arsenate the order of the first two is reversed. The criterion, stings, again made no contribution to the variation between treatments.

The 1940 data are analyzed in table 7.

Table 5.—Analysis of variance of 1939 data taken in the section containing trees of the Delicious variety.

SOURCE OF VARIANCE	DEGREES OF FREEDOM	INJURED FRUIT		WORMS		STINGS		INJURIES	
		Mean Square	F[1]	Mean Square	F[1]	Mean Square	F[1]	Mean Square	F[1]
Block	3	57.40	1.00	160.23	1.15	20.92		259.06	1.13
Treatment	3	202.56	3.54	1107.56	7.96	27.58		1045.06	4.57
Calcium Arsenate vs. Lead Arsenate	1	588.06	10.28	3108.06	22.35			2626.56	11.48
Soybean Flour vs. No Soybean Flour	1	18.06		76.56				175.56	
Experimental Error	9	57.23		139.06		29.14		228.73	

[1] $F = \frac{\text{Mean Square of Treatment (or Block)}}{\text{Mean Square of Experimental Error}}$.

When degrees of freedom are 3 and 9 respectively the value of F at $P=0.05$ is 3.86; at $P=0.01$ it is 6.99. When degrees of freedom are 1 and 9 respectively the value of F at $P=0.05$ is 5.12; at $P=0.01$ it is 10.56.

Table 6.—Analysis of variance of 1939 data taken in the section containing trees of the Jonathan variety.

SOURCE OF VARIANCE	DEGREES OF FREEDOM	INJURED FRUIT		WORMS		STINGS		INJURIES	
		Mean Square	F[1]	Mean Square	F[1]	Mean Square	F[1]	Mean Square	F[1]
Block	3	2819.42	21.83	5090.50	12.59	1208.67	13.80	10,576.17	20.99
Treatment	3	825.08	6.39	2608.50	6.45	66.17		2305.00	4.57
Calcium Arsenate vs. Lead Arsenate	1	2070.25	16.03	6241.00	15.43			5329.00	10.58
Soybean Flour vs. No Soybean Flour	1	324.00	2.51	462.25	1.14			961.00	1.91
Experimental Error	9	129.14		404.44		87.61		503.83	

[1] $F = \frac{\text{Mean Square of Treatment (or Block)}}{\text{Mean Square of Experimental Error}}$.

When degrees of freedom are 3 and 9 respectively the value of F at $P = 0.05$ is 3.86; at $P = 0.01$ it is 6.99. When degrees of freedom are 1 and 9 respectively the value of F at $P = 0.05$ is 5.12; at $P = 0.01$ it is 10.56.

There were no differences among the treatments by any of the criteria used. This indicates that where no real differences occur among treatments all of the criteria respond in a similar fashion.

From the preceding discussion it seems that in the comparison of toxins which have no fumigation effect a consideration of stings is unimportant. Even though there is a difference in the efficacy of treatments, there is no real difference in the number of stings resulting from the various treatments. The number of worms seems to give the most sensitive test and when the use of small samples is necessary this criterion should be given preference. The number of injuries does not give as sensitive a test as number of worms, and since it involves more work it should not be given preference in favor of number of worms. The number of injuries, however, does give a more accurate record because worms and stings may be mistaken for each other. The number of injured fruit lacks the sensitivity of the number of worms but has the advantage that appreciably less work is involved in taking the data. It has most significance to those concerned chiefly with evaluation of insecticides, etc. The practical grower who is concerned with the effect of the codling moth on grades of fruit will be interested in the number of worms, stings, and total injuries. Newcomer *et al.* (1943) point out that observers record the numbers of wormy and stung fruit with greater accuracy than the numbers of worms and stings. The 1940 data do not show the

Table 7.—Analysis of variance of 1940 data.

SOURCE OF VARIANCE	DEGREES OF FREEDOM	WORMY FRUIT		STUNG FRUIT		INJURED FRUIT		WORMS		STINGS		INJURIES	
		Mean Square	F[1]	Mean Square	F[1]	Mean Square	F[1]	Mean Square	F[1]	Mean Square	F[1]	Mean Square	F[1]
Treatment	3	129.56	1.70	74.73	2.37	16.33		957.67	1.54	3973.06	1.03	6498.23	1.05
Block	3	81.39	1.07	317.23	10.07	166.17	9.04	491.17		17,817.40	4.64	14,226.40	2.31
Experimental Error	9	76.12		31.51		18.39		619.94		3839.23		6171.40	

[1] $F = \frac{\text{Mean Square of Treatment (or Block)}}{\text{Mean Square of Experimental Error}}$.

When degrees of freedom are 3 and 9 respectively the value of F at $P = 0.05$ is 3.86.

Table 8.—Analysis of variance of data compared on the basis of the ratio of worms to stings.

Source of Variance	Degrees of Freedom	1939 Jonathan Section		1939 Delicious Section		1940 Delicious Section	
		Mean Square	F[1]	Mean Square	F[1]	Mean Square	F[1]
Treatment	3	5.0937	8.16	17.6024	2.42	0.007875	2.32
Block	3	3.2365	5.20	3.5945		0.015564	4.60
Experimental Error	9	0.6244		7.2677		0.003387	

[1] $F = \frac{\text{Mean Square of Treatment (or Block)}}{\text{Mean Square of Experimental Error}}$.

When degrees of freedom are 3 and 9 respectively the value of F at $P = 0.05$ is 3.86; at $P = 0.01$ it is 6.99.

number of worms to be a more sensitive test than the number of wormy apples, but in the 1939 data the relationship of injuries to injured fruit indicates that it would be more sensitive. Also, a consideration of the relationship between worms and wormy apples of the 1940 data ($Y = 1.112X^{1.2694}$) shows that with increase in size of values the number of worms increases in a greater proportion than the number of wormy fruit. In a sample where there are 5 wormy apples there are 8.6 worms, and in a sample where there are 25 wormy apples there are 66.1 worms. There were 7.7 times as many worms in the second sample as in the first, yet there were only 5 times as many wormy apples. For field experiments in general, the number of injured fruit or the number of wormy fruit will serve satisfactorily in making comparisons of different treatments. In critical studies additional information may be obtained through the use of other criteria.

An index number for rating codling moth treatments was proposed by Melander (1920) in the form of the ratio of worms to stings. This ratio is based on the hypothesis that worms are unaffected by treatment, and that stings represent larvae that were killed by the insecticide before that could enter deeply into the apple. This index implies that a larger number of stings is associated with better insecticide treatment. The data from the 1939 and 1940 experiments have been converted to worm/sting ratios in table 4.

Analysis of variance of the data compared on the basis of the ratio of worms to stings is summarized in table 8. The F values for treatment show that a difference occurs among the treatments of the 1939 Jonathan Section and that no difference occurs among the treatments of the 1939 Delicious Section. Actually a difference occurs in both sections. According to the hypothesis upon which this index is based the more stings there are the more effective the treatments. If a treatment is superior it should have more stings, but no difference was noted in the number of stings of the various treatments. For this ratio to give accurate results all stings must be caused by worms that are killed by the insecticide and all worms that are killed by the insecticide must form stings. In 1940 stings were observed in orchards that had received no insecticidal sprays. Since it has not been shown that all worms killed by an insecticide will form stings, it can be concluded that analyses made on the basis of the ratio of worms to stings are not reliable. Although the worm/sting index is lacking in reliability it was a definite step forward in the days when satisfactory experimental designs were not available.

SUMMARY.—A study of the various types of codling moth injury reveals that the relationship between the number of injuries and the number of injured fruit and between the number of worms and the number of wormy fruit can be expressed by the equation $Y = aX^b$ which varies with locality and season. Use of the ratio, worms to stings, does not give dependable analyses. For field experiments satisfactory comparisons of treatments can be made on the basis of the number of injured fruit or the number of wormy fruit. Other criteria are useful in making more detailed studies.

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A System of Sampling and Rating Codling Moth Infestations[1]

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The method most widely used for sampling apples infested by the codling moth, *Carpocapsa pomonella* (L.) consists of determining the degree of injury in the picked fruit at harvest. Usually the sampling unit is a tree, which, in a well-designed experiment is one of a number of such trees located by chance in an experimental plot. In sampling it is customary to examine at harvest some 50 to 300 of the apples picked from the crop of each sample tree. Each sample is then tallied for degree of injury according to one or several criteria of infestation.

This method provides no information about the progress of the infestation in the pre-harvest period. Size of broods, growth trend of the worm population, and other details of pre-harvest growth are either unknown or imperfectly estimated from trap records or general observations. Lack of pre-harvest information, though disadvantageous when a lead arsenate spray schedule is followed, becomes a more serious handicap when DDT and other new materials are interposed in the schedule. A method which would furnish reliable interim estimates of the performance of toxic materials would seem to be desirable.

This article describes methods of taking pre-harvest samples and of determining the degree of injury in them which have been employed for a number of years by the writer and his associates, and discusses some of the advantages of these methods over the method in current use.

SAMPLING THE TREES.—The system of taking samples to be described departs in two particulars from the method of sampling the picked fruit at harvest: (1) The sample is selected at random in the lower peripheral area of the tree, that is to say, in the area from the ground level to a point as high as the fruit can be examined effectively; (2) The sampled fruit is examined without removing it from the tree.

The adequacy of the lower peripheral area for sampling depends, in so far as Iowa orchards are concerned, on results of experiments extending over several years (Graham & Richardson 1940, 1942; Richardson 1946). Data taken in the lower area have been adequate for assessing the comparative effectiveness of insecticides and spreaders.

It is fairly well known that infestations of codling moth tend to be heavier in the tops than at lower levels of apple trees; it is also recognized that a uniform coverage of spray materials is more difficult to attain in the tops than on the sides of the trees; it is not unreasonable to assume that spray residues are subjected to a greater degree of weathering in the top area than at lower tree levels. In Iowa, Hansberry[2] found a difference of 7.84 percentage points in wormy fruit taken from the upper (36.92 per cent) and lower (29.08 per cent) branches of large Ben Davis trees. This represents a 1.27-fold increase in the upper as compared with the lower branches. Less complete ob-

[1] Journal paper No. J-1475 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 389.

[2] Unpublished thesis, Iowa State College, 1936.

servations on well sprayed trees made several times since have shown comparable differences. Newcomer *et al.* (1943) compared the total injuries (worms and stings) in upper and lower parts of Rome trees in Washington and reported an average of 1.2 times as many injuries per 100 apples in the upper tree area. Although recognizing that some of this difference may have been due to other causes, they concluded that most of it resulted from less thorough spraying of the upper parts. While the codling moth may prefer the upper to the lower parts of trees for oviposition, incontrovertible proof of this appears to be lacking; present information points to greater variability in application and persistence of spray materials as the chief causes of the difference in degree of infestation.

If these conclusions are justified, data on infestation in the lower peripheral areas should furnish a more sensitive comparison of the toxic efficiency of control materials than data from the upper areas; data from the latter areas would be expected to afford a better indication of thoroughness of spray application, weathering of spray materials, etc., while data taken from the entire crops of trees at harvest would present a compromise between conditions in the two tree areas. When the spraying has been done uniformly and thoroughly, differences between the degree of infestation in the upper and lower parts of trees, as indicated above, will generally not be large, and data taken in the lower peripheral areas can be used for making comparative studies of control materials and, perhaps, for other purposes.

The lower peripheral area has several advantages for sampling over the entire tree or over areas at higher tree levels. The operator works on the ground; he can sample the trees at determined intervals during the season without disturbing the crop, and so obtain definite information on the relative size of broods, seasonal trends of the infestation and other subjects. He can work ahead of the pickers at harvest without interfering with harvesting operations.

Records of infestation are taken on apples selected at random as the operator encircles the tree. Apples are examined from the lowest branches to a point as high as can be reached conveniently and are tallied for infestation according to the criterion or criteria selected by the investigator. Difficult cases can be decided by examination with a hand lens or by the use of a knife. Ordinarily, very few apples will be sacrificed in making these observations.

UNIFORMITY OF INFESTATION IN THE LOWER PERIPHERAL AREA.—From time to time, questions have arisen concerning the uniformity of infestation in the lower peripheral area. Incidental observations, covering several seasons, suggested that the fruit on the south sides of these areas

Table 1.—Codling moth infestation in the lower periphery of apple trees, 1946.

LOCATION	DATE OF SAMPLING	NO. OF ROWS	SAMPLE TREES PER ROW	INFESTATION, SIDES OF TREES				
				South	1[3]	2[4]	3[3]	Mean
Mitchellville, Iowa	July 12	11	6	3.94[1] 4.67[2]	4.12 4.36	2.55 2.67	3.82 4.00	3.61 3.92
Mitchellville, Iowa	August 2	3	6	6.89 7.33	7.11 7.78	6.44 7.33	4.00 4.44	6.11 6.72
Mitchellville, Iowa	September 12	7	6	16.19 20.76	13.43 17.43	15.05 18.19	12.38 14.76	14.26 17.79
Mitchellville, Iowa	September 25	4	6	12.33 13.50	13.83 16.83	12.33 14.50	13.83 16.00	13.08 15.21
Ames, Iowa	September 5	[5]	—	2.00 2.20	1.80 2.20	2.00 2.00	2.00 2.20	1.95 2.15

[1] Criterion, percentage of blemished fruit.
[2] Criterion, blemishes per 100 apples.
[3] From east or west sides, or both.
[4] Predominantly from north side.
[5] Data from 20 sample trees.

might be more heavily infested, and earlier, than that on the other sides. If this were true, the system of sampling would require some modification. In 1946 and 1947 uniformity of infestation was studied in two orchards each of which was sprayed throughout the seasons with DDT and DDT-lead arsenate.

Data were taken at Mitchellville, Iowa, in 1946, according to the criteria, number of blemished apples and blemishes (worms+stings) per sample on July 12, August 2, September 12, and September 25, in an orchard consisting principally of Delicious, Jonathan, Grimes Golden, and Northwestern Greening varieties. Samples of 25 apples were examined in the south side of the peripheral area of each sample tree, and 3 samples of 25 apples, distributed as evenly as possible, in the remaining lower peripheral area of the same tree. Ideally, the samples should have been taken from the north, east, south, and west sides, but defects in the shapes of trees and inequalities in the distribution of the crop restricted the number of trees available for sampling by this method. The 3 samples which were unassigned for location were recorded under numbers 1, 2, 3, and were so taken that the samples labeled 2 originated predominantly from the north sides, while those labeled 1 and 3 originated from the east, west or both east and west sides of the trees.

The second orchard, at Ames, Iowa, was sampled several times during the 1946 season according to the same procedure but only by September 5 had the level of infestation exceeded 1 per cent of blemished fruit. The summarized data from both orchards are presented in table 1.

The data from these tree areas were analyzed by making the following comparisons: (I) South vs. North (S—2); (II) Side 1 vs. Side 3 (1–3); (III) South+North vs. Side 1+Side 3 [(S+2)−(1+3)]. These 3 comparisons form an orthogonal set with 1 degree of freedom for each. In addition, an independent orthogonal comparison (IV) was made of South vs. Sides 1+2+3 [(3S)−(1+2+3)]. The data used in both analyses were the numbers of blemished apples in 25 apples and the numbers of blemishes in 25 apples rather than the corresponding percentages. The results of both analyses are presented in table 2.

Table 2.—Analysis of the Mitchellville data, 1946.

DATE	SOURCE OF VARIATION	DEGREES OF FREEDOM	MEAN SQUARE	*F*
July 12	I. South vs. North	1	24.04[1] 49.50[2]	2.58 4.36*
	II. Side 1 vs. Side 3	1	1.14 1.63	
	III. South+North vs. 1+3	1	13.09 6.57	
	IV. South vs. 1+2+3	1	3.67 18.19	
	Rows	10	14.11 18.22	
	Rows×Comparisons (Error)	30	9.31 11.36	
August 2	I	1	0.67 0	
	II	1	32.67 37.50	33.68** 33.78**
	III	1	8.33 10.08	8.59* 9.08*
	IV	1	4.69 5.44	
	Rows	2	3.08 6.33	
	Error	6	0.97 1.11	
September 12	I	1	10.29 52.07	
	II	1	8.64 56.00	
	III	1	134.96 180.04	
	IV	1	78.11 186.01	
	Rows	6	126.66 216.81	
	Error	18	45.32 89.84	
September 25	I	1	0 4.50	
	II	1	0 3.12	
	III	1	20.25 52.56	
	IV	1	78.11 186.01	
	Rows	3	15.42 32.90	
	Error	9	33.69 68.40	

[1] Upper figure, blemished fruit per 25 apples.
[2] Lower figure, blemishes per 25 apples.
* Probability 5 per cent or less but not 1 per cent.
** Probability 1 per cent or less.

Significant differences in the comparisons are found only in the data of July 12, comparison I, for blemishes in which the *F* value just reaches significance for a probability of 5 per cent, and of August 2,

Table 3.—Codling moth infestation in the lower periphery of apple trees, 1947.

Location	Date	No. of Rows Sampled	No. of Trees Sampled	Percentage of Blemished Fruit in:				Mean Percentage	χ^2
				N	E	S	W		
Mitchellville, Iowa	July 9	12	288	4.58	2.36	4.17	3.61	3.68	5.53
Mitchellville, Iowa	August 20	10	80	24.50	7.00	20.50	17.00	17.25	19.51[2]
Mitchellville, Iowa	September 9	5	9[1]	16.44	10.67	16.44	15.11	14.67	3.46
Ames, Iowa	July 18	18	336	0.12	1.07	0.60	1.55	0.83	11.42[2]
Ames, Iowa	August 11	18	96	4.58	1.67	1.67	3.33	2.81	5.15

[1] Samples of 25 apples were tallied on each of the 4 sides of the trees on 9–9; on all other dates, a sample of 10 apples was tallied on one side of each tree.
[2] These χ^2 values indicate heterogeneous data.

in which comparison II is highly significant ($P=0.01$), and comparison III is significant at the 5 per cent level for both criteria. The August 2 data originated from a smaller number of trees than the data taken on other dates. It is believed that the relatively large deviations observed in these data were due to chance sampling variations. No significant differences were found in the comparison, South vs. Sides 1+2+3, in the data taken on any date and according to either criterion. The data from Ames, Iowa, obtained on September 5, are remarkably uniform and lend support to the evidence from Mitchellville.

The data for 1947, taken in the same orchards, are presented in table 3.

The fruit on the north, east, south and west sides of the sample trees was tallied separately according to the criterion, number of blemished apples. Except at Mitchellville on September 9, only one side of each sample tree was examined and the sample was 10 applies; on September 9, the four sides of each sample tree were examined, the sample being 25 apples in each side.

The data taken at Mitchellville on July 9 and September 9 show good uniformity with the east sides giving the lowest infestation. The data for August 20 are heterogeneous with the lowest infestation again on the east sides. The data from Ames, obtained on July 18, when the mean percentage of blemished fruit was 0.83, were heterogeneous even though nearly half the trees in the experimental plot were included in the examination. On the next examination (July 11), the mean percentage had increase to 2.81, and the data then showed good uniformity.

Considered as a whole, the observations indicate that one side of a tree is about as good as another for sampling purposes but when once a particular side has been chosen for sampling, it should be sampled on all succeeding dates. There is no indication that infestations are consistently larger on south sides than on other sides of the trees. It is probable, also, that a minimum of 25 apples rather than 10 apples should be examined on any one side of a sample tree and if the entire lower peripheral area is included then at least 50 apples should be tallied. The general level of infestation in the experimental area will have much to do with the size of the tree sample chosen.

Criteria of Infestation.—There appears to be little choice between the two criteria of infestation used in the 1946 study. Blemished apples per unit was as sensitive as blemishes per unit. Graham (1947) has recently studied the relationship of the criteria based per unit on blemished apples, blemishes, wormy apples, worms, stung apples, stings and the ratio of worms to stings. Worms per unit gave the most sensitive analysis while stings per unit did not differentiate treatments although treatments by other criteria showed significant differences. Blemishes per unit proved to be a less sensitive criterion than worms but it is recorded somewhat more accurately because worms and stings may be confused. Graham's records were taken on picked fruit. In sampling fruit on the tree, the writer has also found blemishes per unit to be more easily and quickly recorded than worms or stings. Most rapid and convenient of all criteria to use is blemished fruit per unit. Furthermore, data taken according to this criterion seem to be suitable for the differentiation of insecticides and spreaders, and perhaps for other purposes. Other criteria, as

Graham points out, may be advisable for refined analyses or for special purposes. It is doubtful whether differences in the efficiency of insecticides of practical significance to apple growers, will be found that cannot be differentiated statistically on the basis of data from blemished apples per unit alone.

EFFECT OF SIZE OF CROP.—In some regions of the United States, a correlation appears to exist between crop size and the degree of codling moth infestation. Such a correlation was recognized in Iowa as early as 1879; and in the period from 1890 to 1934, coincidence of light crops with moderate to heavy infestations and of heavy crops with light to moderate infestations was the rule in this state although exceptions were noted (Richardson & Hansberry, 1934). This tendency can be equalized by including among the sample trees only those with approximately equal crops. For most purposes, it is sufficient to estimate crop size from the ground.

EFFECT OF FRUIT DROP.—If dropping of fruit is not excessive, inclusion of the fallen fruit adds little to the information gained from sampling the fruit remaining on the tree (Hansberry 1936; Newcomer *et al.* 1943). When dropping becomes excessive, a record of infestation in the dropped fruit may be necessary. This can be done by tagging a sample of fruit in the periphery of an adequate number of sample trees and determining on the next record date, the number that have fallen and their condition with respect to infestation. The decreased sample remaining on each tree is then made up to standard size by tagging a sufficient additional number of apples (and, of course, noting at the time their condition of infestation).

SUMMARY.—Methods of evaluating insecticides for codling moth control which depend on data taken from picked fruit at harvest furnish no information on the preharvest trend of infestations or on the relative size of broods, and they provide no basis for changing the dosage, kind, and number of insecticide applications in the pre-harvest period.

A method is proposed for taking preharvest infestation data. It uses the lower peripheral area of the tree as the sampling unit. Apples are tallied according to one or several criteria of infestation by chance within this area without removing them from the tree. The data furnish an index of infestation of sufficient statistical uniformity for the evaluation of insecticides, spreaders, and perhaps for other purposes. The operator samples the trees from the ground at any time before or at harvest without disturbing the crop or interfering with harvest operations.

Either the entire lower periphery of the trees or any one-fourth of this area provides suitable sample units. South sides of trees were not significantly more heavily infested than other sides.

Effects of crop size and of dropped fruit on pre-harvest sampling are discussed and ways of accounting for them are suggested.

For speed and convenience the criterion, total number of blemished (infested) fruits per unit sample, is most suitable for obtaining infestation data. Other criteria are discussed, and it is pointed out that blemished fruit per unit is probably adequate for detecting any difference between insecticides of practical value to apple growers.—12-12-47.

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Comparison of Methods for Testing Repellent-Type Fly Sprays[1, 5]

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It is now generally appreciated that experimental work with cattle fly sprays under field conditions is an extremely complex type of research if adequate account is taken of the many variables involved. The difficulties have been increased recently by the introduction of sprays which are primarily toxicants rather than primarily repellents, especially if attempts are made to compare sprays of both types. The toxicants tend to reduce the fly populations and therefore would add to an already complex picture a changing population of flies about the cows.

Fryer *et al.* (1943) pointed out the necessity of a properly planned experiment so that the data could be analyzed by the best statistical methods now available That paper was intended, in part, to encourage persons who are experimenting with cattle fly sprays to give more thought to the design of their tests so that real progress may be made in this complex field.

The literature at that time revealed that two general procedures were being employed: the whole-cow and the half-cow methods. In the whole-cow method, the cattle available for the tests are segregated into groups which are equal in numbers and approximately equal in attractiveness to flies. The number of groups of cows is the same as the number of sprays (including check) to be tested. Thereafter, each group is sprayed with a different repellent spray according to a suitable experimental plan, and the actual numbers of flies found on the groups of cows are used as the basis for determining the effectiveness of each of the repellent sprays under test. This is the method which was used during the summers of 1941 and 1942 at the Kansas Agricultural Experiment Station.

The half-cow technique is used in an attempt to reduce the deleterious effects of cow-to-cow variability by comparing sprays on the same cow. Such a procedure is comparable to the well-established technique of comparing different suspensions of tobacco mosaic virus, for example, on the half-leaves of tobacco plants. However, there is one apparent difference which could be important: as a fly approaches an animal in a half-cow test it has a choice of a side upon which to land, and probably a second choice as to whether or not it will stay there and feed at all if it makes that choice quickly enough.

The probability that a fly will land on a side with spray S_1 on it may depend on what spray is on the other side. Thus there may be interference between the two sprays on the same cow and possibly some resulting confusion in the final measurement of the repellent or toxic qualities of both of those sprays. With toxicants there is the additional—and apparently insurmountable—difficulty with the half-cow method that the fly population is continuously reduced by an effective toxicant, and therefore, the effectiveness of one toxicant would accrue to the benefit of both. In the extreme case no spray at all would appear eventually to be effective if a good toxicant were on the other side of the same cow.

In the paper mentioned above, it was suggested that both the half-cow and whole-cow techniques could be much improved by the use of modern statistical methods, both in the design of the experiments and in the analysis of the resulting data. In particular, a latin-square type of design was suggested for the whole-cow tests and a symmetrical pairs design for the half-cow procedure.

To test the reliability of the half-cow and the whole-cow techniques during fly spray tests in the field, those two methods were employed simultaneously during the summer of 1942. Also, the trials were

[1] This publication is a report on some phases of a cooperative investigation involving the Departments of Entomology, Dairy Husbandry, and Mathematics at Kansas State College, and supported by a fellowship established at the Kansas Agricultural Experiment Station, June, 1940, by the Hercules Powder Company, Wilmington, Del.

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repeated after an interval of about a month to determine whether the fundamental relationships remained essentially the same throughout the summer. Three thoroughly-tested repellent-type sprays were used in both the whole-cow and the half-cow trials, thereby making possible a direct comparison of those two techniques on the basis of cattle fly repellents of known effectiveness.

In view of the fact that the recent war interrupted the analysis and reporting of the results, and because revolutionary developments in types of sprays have taken place in the meantime, this paper is presented as a study of techniques rather than as a comparison of particular sprays. The sprays will be designated merely as S_1, S_2, S_3, and S_4 (check).

It is believed that the general conclusions drawn herein should be of value in designing future experiments to measure the relative effectiveness of newly-developed sprays available now or in the future. Whether the spray be a repellent or a toxicant, the purpose of applying it to cows is to keep them as free of flies as is possible and practicable. It is assumed that the spray which allows the fewest flies to be found on the cows at the counting periods is the best spray under the given conditions, whether the purpose in keeping the flies off be the humanitarian one of providing contentment for the cattle and their handlers or the economic one of possibly producing more milk or beef.

In the preliminary research on DDT sprays, the results were so obvious that little need for statistical methods was felt. But, sooner or later any such research may come to the point where adjustments of the amounts of the sprays applied and a study of the residual effects will demand careful mathematical measurements. Casual observation will have become inadequate. When any such experimentation has reached the stage at which such mathematical measurements as fly counts, weights, or gains are needed, then the research will benefit by the application of proper statistical methods from the start of the experimentation. The discussion given herein is intended to be beneficial in fly spray tests which have reached that non-obvious stage.

EXPERIMENTAL.—All of the dairy cattle employed in this study were first subjected to a 4-day uniformity trial for the purpose of determining their susceptibilities to flies. It is well known that cattle differ widely in their attractiveness to flies; so it was deemed advisable to use balanced groups of cows, even for the half-cow phases of the tests.

Four three-cow groups were assigned to the whole-cow tests and two six-cow groups to the half-cow trials upon the basis of the counts made during the uniformity trials. The groups of cattle to be placed in that portion of the experiment devoted to the whole-cow method were made as nearly alike as possible with respect to total susceptibility to flies; but the cows to be employed under the half-cow technique were divided into a low-susceptibility and a high-susceptibility group to determine whether there was any indication of an effect due to the numbers of flies around the cows. The data taken from those two latter groups were analyzed separately.

A 7×7[6] latin square with groups of three cows as the "cells" of the square was employed during the whole-cow phase of this research. That general procedure was described in detail by Fryer *et al.* (1943). When the experiment was replicated later in the same summer, the same cows were used but the rotation of the sprays among the groups of cows was determined by means of another randomized 7×7 latin square.

A statistical plan known as a symmetrical pairs design was employed in that portion of the experimentation which involved the half-cow method for studying fly sprays. That general arrangement was described by Yates (1936), and was suggested by Fryer *et al.* (1943) for use in the half-cow method.

Although the basic design of the half-cow tests was of the symmetrical pairs type, it was considered desirable to continue the counts over several hours of several days, and eventually to make every possible comparison of the sprays on each cow which took part in that research. Such a procedure is not essential to the half-cow method, but was adopted here so that the comparison of the half-cow and the whole-cow techniques would be as complete as possible. Only four sprays (including check) were tested

[6] A 7×7 latin square was employed in the whole-cow tests so other sprays than those in the half-cow tests could be studied too.

in the half-cow trials, due to limitations on the number of cows available for this study. Yates (1936) pointed out that n(n-1)/2 comparisons are possible among n sprays (or whatever is being tested); therefore six comparisons are possible with three sprays and check. A convenient device for making those comparisons for three days on each cow in the experiment is to form a 6×6 latin square with the six cows as the "columns" and the six three-day periods serving as the "rows" of the square. The specific design for one part of the half-cow research is shown in table 1, with the sprays designated simply as S_1, S_2, S_3, S_4 (check).

The flies on each cow (or half-cow) in both the whole-cow and the half-cow experiments were counted and recorded at 8:30, 9:30, and 10:30 a.m.; and 1:30 and 2:30 p.m. of each day. Such periodic counts made it possible to study the way in which the effectiveness of each spray decreased during the day. When the newer DDT insecticides are being studied, one obviously needs to use more widely spaced intervals of time to study the manner in which the toxicities of the spray diminish in the field.

Table 1.—The basic statistical design employed in series 2, low-susceptibility group, of the half-cow tests.

Period	Side	Cow 1	2	3	4	5	6
I	left	S_1	S_1	S_2	S_3	S_4	S_1
	right	S_4	S_2	S_3	S_4	S_2	S_3
II	left	S_3	S_4	S_1	S_4	S_3	S_4
	right	S_1	S_3	S_2	S_1	S_2	S_2
III	left	S_3	S_3	S_4	S_2	S_4	S_4
	right	S_2	S_1	S_2	S_1	S_1	S_3
IV	left	S_1	S_3	S_1	S_4	S_4	S_1
	right	S_2	S_2	S_3	S_2	S_3	S_4
V	left	S_2	S_4	S_1	S_3	S_1	S_3
	right	S_4	S_2	S_4	S_1	S_2	S_2
VI	left	S_2	S_1	S_2	S_2	S_3	S_2
	right	S_4	S_4	S_4	S_3	S_1	S_1

The cattle were thoroughly washed with soap and water to remove the spray residues at the end of each 3-day period when different sprays were to be applied. During each day of the tests the cows were tethered individually in a pasture on the dairy farm at Kansas State College.

It was indicated in the earlier paper by Fryer *et al.* (1943) that it already had been established that a competent person can count accurately the flies on a cow under field conditions; hence no further investigations along that line were conducted.

TRANSFORMATION OF THE DATA.—In the paper by Fryer *et al.* (1943) considerable attention was given to the matter of mathematically transforming the actual fly counts to obtain data which could be analyzed properly by the available statistical methods. It was explained that the raw data represented by such counts typically exhibit serious non-homogeneity of variances among the groups of counts, such as are determined by the different sprays, cows, or periods of days. Such inequalities in variance must be removed effectively before the statistical techniques available are suitable for the analysis of the data, as is explained in the paper by Fryer *et al.* (1943).

Several mathematical transformations of fly counts of this sort were studied during the three summers of cattle fly spray testing at the Kansas Agricultural Experiment Station. Neither the square root nor the logarithmic transformations, which might be expected to apply to this sort of research, was successful for equalizing the group variances in the data taken during the first two summers of research (which were analyzed simultaneously). Therefore it was considered necessary to devise a new transformation, later called the reciprocal square root transformation. At the same time it was decided that an unnecessarily large number of zero counts was being obtained by making the counts so soon after the sprays had been applied that all sprays were completely effective. In these investigations the relative effectiveness of each spray compared to the others was the chief matter under study. Obviously no count can be below zero. It is equally obvious that two sprays may each be good enough to keep all of the flies off a cow early in the morning and immediately after spraying and yet have widely different qualities as repellents or as toxicants; but in terms of fly counts they would appear equally effective.

A statistical study of the data obtained during the first two summers of work on this problem led to the suggestion that the first counts be taken 2 hours after the spray had been applied. More satisfactory data were obtained, but the statistical

Table 2.—A period-by-period comparison of the whole-cow and the half-cow methods of testing cattle fly sprays in the field. (Based on the transformed counts taken during series 2.)

A. WHOLE-COW METHOD. Source of Variation	Degrees of Freedom	Estimated variances (mean squares) by periods I	II	III	IV	V	VI
Sprays	3	10.13	35.45	28.74	17.34	2.66	9.91
Hours	4	6.64	12.23	18.17	3.08	1.73	22.80
Spray×hour	12	0.39	0.65	2.81	0.61	0.28	0.58
Remainder	150	0.28	0.14	0.35	0.39	0.29	0.28

B. HALF-COW METHOD. Sources of variation	Degrees of Freedom	Estimated variances (mean squares) by periods I	II	III	IV	V	VI
Sprays	3	1.86	3.41	0.73	1.59	0.76	2.77
Hours	5[1]	8.90	8.43	11.47	2.80	3.46	8.19
Spray×hour	15	0.40	0.48	0.43	0.38	0.22	0.68
Remainder	185	0.53	0.45	0.55	0.52	0.43	0.52

[1] Actually, a 3:30 P.M. count was taken; so results are included here.

distributions were so altered that the reciprocal square root transformation was no longer successful in equalizing the variances among the several groups of measurements of fly repellency. The logarithmic transformation was adequate for that purpose; so it has been employed in the analyses reported herein.

The question as to which mathematical transformation to use when data of this type have been taken must be studied statistically before a procedure finally is adopted. The paper by Fryer *et al.* (1943) reviews the literature on the subject.

STATISTICAL COMPARISONS OF TECHNIQUES.—All of the statistical analyses discussed below are based on measurements of fly repellency derived from the mathematical formula $Y=\log_e(X+1)$, wherein the X=the actual number of flies.

The statistical analyses of the data derived from the whole-cow tests follow the general pattern described by Fryer *et al.* (1943). In addition, it is possible and useful to analyze the data period-by-period in order that one can obtain some information about the length of time that a test must run before the conclusions are likely to be reliable. This was done with the data from the whole-cow tests.

The measurements of repellency taken during the half-cow tests were analyzed by a direct application of the method of least squares because this particular design was not known to have been applied previously in this same form. The data taken during the use of the half-cow method were analyzed period-by-period, and also as a whole experiment for the reasons given above for the whole-cow tests.

In general it was discovered that the half-cow method led to some confused and highly improbable conclusions even when considered over the whole period of the tests. The nature of this confusion is studied by means of the statistical summaries which follow. In addition the type of information which can be obtained from the whole-cow type of experiment is illustrated.

Table 2 contains a period-by-period comparison of certain portions of the analyses of variance from the half-cow and the whole-cow trials during series 2. Series 2 was chosen for illustration chiefly because it was felt that the assistants conducting the tests then would be more experienced and hence would be even less likely to commit errors than during series 1. However, the results of the two series of trials are so similar as regards the fundamental comparison of the half- and the whole-cow methods that it makes no difference which is used for illustration.

When the F-Test is applied to part A of table 2, it is learned that:

(a) A definitely significant spray×hour interaction is found only in periods II, III, and VI. This interaction is important because it helps to compare the lasting qualities of the sprays.

(b) The probabilities associated with the F-ratios for the spray×hour variances are approximately the following: .18, <.001, <.001, .10, .50, and .022. When those probabilities from six independent significance tests are compounded by the method due to Fisher (1936), (1942), after making rough but conservative

estimates of the indefinite probabilities above, it is found that the magnitude of chi-square is in the neighborhood of 50 with but 12 degrees of freedom. Hence it appears that there surely is a significant spray×hour interaction, even though it does not show up as statistically significant during every period of the experiment.

(c) The estimates of variance obtained from the differences among the sprays were always significantly greater than those obtained from the spray×hour interaction; hence one expects to find that one or more sprays were consistently superior to others throughout the tests of any period.

(d) Significantly different numbers of flies were observed at the various counting periods of each day, as is to be expected.

When the F-test is applied to part B of table 2, pertaining to the half-cow method, it is learned that:

(1) There is no hint of a spray×hour interaction during any period or in the total picture obtained by compounding the probabilities from the significance tests made for the separate periods of the experiment.

(2) Spray differences are statistically significant in all but the third period, but are of much smaller magnitude than during the whole-cow trials.

(3) The hour variation is somewhat comparable to that under the whole-cow technique, and it is always statistically significant.

(4) The remainder variance under the half-cow method is always greater than that under the whole-cow method, when one might expect it to be less in view of the fact that the half-cow procedure is supposed to cut down on extraneous variations such as make up the remainder variance in the above analyses.

The analyses of table 2 indicate that the two techniques under study do not give comparable results in some important respects, with the half-cow method being the less decisive of the two. It should be recalled in this connection that the sprays being used in this research are of proved efficiency aside from S^4 (check), of course. As a matter of fact, one spray is a 4 per cent solution of *Lethane*, another is a 3 per cent solution of *Thanite*, and the other is another 3 per cent solution of *Thanite* in an oil of a different viscosity.

It is preferable that the foregoing data finally be analyzed as a whole series of measurements in accordance with the design of the experiment, because three days is too short a period of time to obtain a consistent estimate of the efficiency of the sprays or of the techniques being used. Such an analysis is presented in table 3 for the second series of trials, series 2 being chosen for the reasons given earlier.

Table 3.—Analyses of variance of the data from the whole- and the half-cow tests, series 2, after the logarithmic transformation had been used to obtain satisfactorily normal frequency distributions.

Sources of Variation	Half-Cow		Whole-Cow	
	Degrees of Freedom	Variance	Degrees of Freedom	Variance
Sprays	3	1.135	3	85.477
Hours	5	39.545	4	37.514
Periods	5	6.604	6	16.091
Cows	5	32.681	20	19.695
Days in period	12	4.887	14	3.238
Spray×hour	15	0.376	12	5.271
Spray×period	25	3.932	18	4.165
Remainder	1225	0.485	1182	0.336
Total	1295		1295	

Table 3 justifies the following conclusions:

(1) The remainder variance under the half-cow method is significantly higher than that under the whole-cow method, which is contrary to expectation as indicated above with regard to table 2.

(2) There is a definite spray×hour interaction during the use of the whole-cow technique but none under the half-cow method, which means that one method produces results which are disputed by the data from the other method of research. It will be shown that the conclusion from the whole-cow data is the more likely to be true in this case.

(3) The two analyses agree quite well (based on the F-test) in regard to the following sources of variation: hours, cows, days in period, periods, and spray×period. That is rather substantial agreement regarding matters which should be unaffected by the close proximity of two sprays on the same cow. This agreement should serve to indicate that the whole-cow and the half-cow tests actually were conducted impartially and under the same environmental conditions, as was claimed above.

(4) There was a spray×period interaction under both techniques. That indicates the presence of significant spray differences (as was noted for each separate period but III) even under the half-cow method; but apparently those differences were so small under that method or so inconsistent that they became obscured somehow in the total picture.

(5) The whole-cow technique shows up significant and consistent spray differences in the matter of fly repellency, even beyond the 0.1 per cent level of statistical significance.

Additional light is thrown upon the kind of information which the whole-cow and the half-cow techniques give in this study by a comparison of the rank orders of the sprays at the five common counting periods of each day. That is accomplished in table 4 by listing the sprays symbolically with the most effective at the top. A significance statement associ-

ated with a specific probability is not possible with these selected comparisons, but a conservative estimate of the least significant average difference in repellency can be obtained. Such differences between adjacent sprays in the rank-order table below are indicated by the symbol,*, placed midway between the symbols for the several sprays. Ties are indicated by a bracket, with it being understood that those sprays whose average repellencies do not differ beyond the bounds of reasonable sampling variation will be considered as equally effective.

The information presented in table 4 leads to the following conclusions:

(1) The observed orders of the sprays as regards repellency are in rather good agreement between the whole-cow and the half-cow methods; but there is never a statistically significant difference under the half-cow procedure. In other words, the observed differences in repellency are within the bounds of reasonable sampling variation as conventionally accepted. When it is recalled that S_4 is check—that is, no spray at all—such a conclusion is absurd. The whole-cow data clearly indicate the inferiority of S_4, and by 9:30 have begun to differentiate the better sprays from the poorer.

(2) Under the whole-cow technique, there is definite evidence to corroborate the spray×hour interaction shown in the analysis summarized in table 3. It shows up in this manner: S_1 started out the day in a tie with S_2 and S_3, but lost its effectiveness faster than those two sprays. In fact, by 2:30 S_1 was little, or no, better than no spray at all.

(3) The conclusion drawn from table 3 that certain spray comparisons would be found to have remained consistent throughout the day is supported by the information in table 4. Sprays S_2 and S_3 were about equally effective throughout the day, and they were at least as effective as S_1 at all times (after allowance is made for sampling variation).

The foregoing analyses and discussions have shown that the half-cow technique can lead to conclusions which are notably different from those derived by the whole-cow method of conducting fly spray research under field conditions. In addition, the results which the half-cow method produced were found to be illogical and confused under the sampling conditions which existed at the Kansas Agricultural Experiment Station.

It already has been suggested that a part of the confusion which occurred during the half-cow tests might be the result of interference between the repellents on the same cow so that the effectiveness of a particular spray was dependent upon the repellent which was applied to the other side of that same cow. If that be true, the data obtained from such research are likely to be difficult to analyze and to interpret, or even worthless. In an attempt to study the matter of interference between the sprays applied to the same cow simultaneously, the average transformed counts obtained for each spray when each of the other sprays was, in turn, applied to the other sides of the same cows are recorded in the table below. For example, 2.01 is the average transformed fly count for spray S_1 for all times when spray S_2 was on the other side of the same cow.

Table 5.—Spray means (from transformed counts) classified according to the spray on the other side of the same cow, low-susceptibility groups. Each average is based on 324 counts.

Spray Being Considered	Series 1				Series 2			
	Spray on other side				Spray on other side			
	S_1	S_2	S_4[1]	S_4[2]	S_1	S_2	S_4[1]	S_4[2]
S_1	—	2.01	2.12	1.68	—	2.45	2.48	2.48
S_2	1.88	—	1.89	1.87	2.50	—	2.60	2.66
S_3	2.10	1.90	—	1.92	2.75	2.78	—	2.82
S_4	1.77	1.95	1.99	—	2.69	2.91	2.91	—

[1] The S_4's of the two series are not the same spray.
[2] S_4 is check: that is no spray at all.
Within the same row and series of the above table, a difference less than 0.15 should be considered as being the consequence of sampling error.

It appears from table 5 that during series 1, spray S_2 did perform consistently no matter which spray happened to be on the

Table 4.—Rank orders of repellency of sprays used in both the half-cow (H-C) and the whole-cow (W-C) trials, series 2, low-susceptibility group. S_4 is check.

8:30 A.M.		9:30 A.M.		10:30 A.M.		1:30 P.M.		2:30 P.M.	
H-C	W-C	H-C	W-C	H-C	W-C	H-C	W-C	H-C	W-C
S_3	S_3	S_2	S_2	S_4	S_2	S_4	S_3	S_2	S_2
S_1	S_1	S_2	S_3	S_2	S_3	S_1	S_2	S_3	S_3
S_2	S_2	S_4	S_1*	S_1	S_1*	S_3	S_1*	S_1	S_1*
S_4	S_4*	S_1	S_4*	S_4	S_4*	S_2	S_4*	S_4	S_4

other side of the same cow. Sprays S_1 and S_3 did not do so. In series 2, the situation is just the reverse: S_1 and S_3 were consistent whereas S_2 was not. The fact that any particular spray's repellency depends in some unpredictable way on the spray on the other side of the same cow, and changes from one series of tests to another even under very similar conditions, would seem to make it quite difficult to devise a suitable measure of repellency under the half-cow technique. It also appears likely that this variable repellency is the major reason why the whole-cow and half-cow techniques gave notably different conclusions during the research described in this paper.

DISCUSSION.—Although the research reported herein was devoted principally to a critical comparison of the half-cow and the whole-cow techniques, it also offered an opportunity for a re-evaluation of some of the specific procedures which had constituted the whole cow-method as applied at the Kansas Agricultural Experiment Station.

After three summers of testing cattle fly repellents under field conditions, there is no reasonable doubt remaining regarding the general necessity for, and usefulness of, statistical methods in this complex type of research. Many of the causes of variability among the numbers of flies found on cows under given environmental conditions are best, or only, controlled statistically. Some of those sources of sampling variation are cow-to-cow differences in attractiveness to flies, weather conditions, the unequal fly populations about the cows from one period of time to another, and possibly the human inability to spray cows evenly and with the same amount of spray per unit area.

The research at this experiment station has demonstrated that the specific whole-cow methods employed here are acceptable from the statistical point of view, and also will produce the sort of information which such experiments are designed to obtain. For example, it has been found that this type of investigation will benefit greatly from the use of a preliminary testing period during which the individual susceptibilities of the cows to the flies about them are studied. Such a procedure makes it possible to divide the cattle into groups of approximately equal attractiveness to flies and thus avoid possible harmful interactions between susceptibility to flies and weather conditions, for example.

Furthermore, the preliminary period offers an opportunity to learn how soon to start the counting after the sprays have been applied and yet avoid a preponderance of undesirable zero counts. That general technique should apply as well to tests of DDT, *Rhothane*, and chlordan, for example. If the purpose of the experiment were to study the role of sprays in milk and beef production, it would be necessary to make certain during the preliminary trials that all those factors which affect such production also were balanced and made subject to statistical control during the experiment. After the procedure just described, a latin square type of design will produce a suitable plan for carrying out the tests in such a manner that proper statistical analyses then can be applied to the data obtained from the research.

During the research on repellent-type sprays at this experiment station, it was learned that with fly populations comparable to those found here, periodic counts of flies should be made during the day starting about two hours after the spray has been applied and continuing at hourly or bi-hourly intervals during each day. Daily, weekly, and even monthly counting periods would be needed with toxicants like DDT, depending on the concentrations of the mixtures employed and upon the specific purposes of the study. An investigation of milk or of beef production might demand only occasional counts designed to describe the fly popultions under which the research was conducted; but such information is vital to the study because obviously there is little point to a study of the benefits of sprays to beef and milk production in the absence of adequate information regarding the degree of fly annoyance against which the cattle were protected.

Another matter which is important to research on either repellents or toxicants but which would require additional study when toxicants are involved is the anormality of the statistical distributions of fly counts. The investigations reported herein, and earlier, from the Kansas Agricultural Experiment Station show that it may be necessary to apply mathematical transformations to the data before the t–test and the F–test techniques

can be employed legitimately. However the final results of the tests could be expressed in terms of the original measurements if that is considered desirable.

There is another matter regarding the planning of experiments on toxicants which would be expected to be different from plans appropriate to tests of repellent sprays. This study has revealed that two repellents on the same cow can interfere with each other to a serious degree. Obviously if a potent toxicant can reduce the fly population over a considerable area not only is the half-cow method not useful at all but the whole-cow method must also provide for an adequate segregation of the several groups of cows carrying the different toxicants on them. Extreme care then would be needed to make sure that the fly populations were satisfactorily equal in the several areas used, or that accurate information about the inequality of the populations was obtained as a basis for interpreting the data taken.

SUMMARY AND CONCLUSIONS.—This paper contains a report of a critical comparison of the whole-cow and the half-cow methods for conducting field tests on cattle fly repellents. Although entomologists and animal husbandmen are now quite interested in new toxicants like DDT, *Rhothane*, and chlordan, considerable interest still remains in the repellent-type sprays. Moreover, there are several important features common to the research on repellents and that on toxicants.

The studies reported herein involved a total of 2592 counts of flies on cows during each of two 18-day series of tests of the half-cow type: and, 1260 counts during each of the two 21-day series of tests under the whole-cow technique of fly spray testing. Those counts were distributed throughout each day of the trials by five counting periods for the whole-cow research, and by six counting periods for the half-cow tests. The only reason for the extra counting time under the half-cow technique was to gain some additional information about a method which had not been studied previously at this experiment station.

The whole-cow research described herein employed latin squares for the planning of the actual conduct of the experiment. The half-cow tests involved a statistical design known as a symmetrical pairs design. Latin squares were used in conjunction with the symmetrical pairs design because it was thought to be desirable in this study to test every spray against every other spray for a period of time on every cow in the tests.

The investigations described above plus a background of two previous summers of research on the same sprays have led to the general conclusion that the whole-cow method is definitely superior to the half-cow procedure in the matter of testing cattle fly repellents under field conditions. Moreover, the whole-cow method gives reliable information about the matters that are of importance in cattle fly spray tests of that sort. It seemed from the rather extensive tests at the Kansas Agricultural Experiment Station that the half-cow technique is rendered almost wholly useless by some sort of interference between the two sprays on the same cow. The exact nature of that interference is not known, but it was sufficiently serious that the half-cow method led to the absurd general conclusion that all of the sprays were equally ineffective, none even being consistently superior to no spray at all. This occurred with sprays which already had been proved here and elsewhere to be effective repellents.

In view of the fact that the whole-cow method was found to be satisfactory and also superior to the half-cow technique, the following suggestions are given for conducting such research on repellent sprays under field conditions. Modifications of this general procedure designed to adapt it to critical field tests of toxicants have been mentioned in the previous section.

(1) The whole-cow type of research should include a preliminary period during which evidence is obtained regarding the susceptibilities of the cows to flies. During that same preliminary trial one can determine how soon to start the counts after the spray is applied. It has been found to be important to avoid a preponderance of zero counts during the early counting periods. Not only are the statistical distributions of the counts adversely affected, but the zero counts also provide poor measurements of the relative effectiveness of a spray.

(2) Upon the basis of the preliminary

trials described in (1) the cows to be employed in the study can be segregated into groups containing three or more animals, depending upon the number of cows available and upon their variability in attracting flies.

(3) A latin square design should be used to determine how the sprays are to be rotated from one group of cows to another during the tests.

(4) Counts should be made periodically of the numbers of flies on each cow of each group throughout each period designated in the plan for the experiment. With sprays and fly populations comparable to those at this experiment station, the counts should be started about two hours after each spray has been applied and should continue at appropriate intervals (see table 4) throughout most of each day.

(5) The fly counts obtained during the research will need to be transformed mathematically into measurements of repellency which approximately conform to a normal frequency distribution. It seems likely from this study that the logarithmic transformation $Y=\log_e(X+1)$ will be satisfactory if the above suggestions regarding zero counts are observed. However, this matter must be checked by statistical analysis before a final decision is reached.

(6) When the transformed measurements of fly repellency have been obtained, the t-test and F-test techniques are available for the analysis of the data.

The present literature indicates that the insecticidal qualities of DDT, for example have been so sensational when compared to the older sprays that the superiority of a sufficiently potent mixture of DDT in keeping flies off cows is obvious without careful numerical measurements. Such experiments essentially would be mere demonstrations. The situation regarding the beneficial effects of cattle fly sprays in terms of milk and beef production is considerably different for these reasons: (a) the sprayed and unsprayed groups of cattle must have been wholly comparable before spraying as shown by specific numerical measurements, because the final results of the tests are to be expressed and interpreted numerically; and (b) if the sprayed animals do produce better than the unsprayed, a numerical measure of the minimum average gain due to spraying may be needed so it can be matched against the cost of the spray to see if it paid for itself. Hence, it appears certain that such research is as fully in need of statistical procedures as that discussed in the major portion of this paper.

The general statistical methods suggested in this paper apply to any critical experiments in which it has been felt necessary to take and to analyze carefully numerical measurements before valid conclusions can be drawn. That, in fact, is the only general circumstance under which statistical methods are particularly useful in this type of research.—12-18-47.

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Synergistic Action of Chlordan in Dusts Containing Nicotine or Rotenone[1]

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Synergism is a term commonly applied to the action of mixtures of two or more insecticides which gives higher mortality than the additive mortality produced by the components used separately. This definition is so loose that one might find synergism in almost any combination of insecticides. As a correct approach for the determination of synergism, Bliss (1939) first suggested a mathematical solution. His method of treating synergism was soon followed by Finney (1942) and Swisher (1944) with more or less modification. To avoid the complexity of the methods used by the above authors Wadley (1945) suggested a short-cut based chiefly on a graphic solution.

JOINT ACTION OF CHLORDAN AND NICOTINE.—The joint action of chlordan and nicotine was tested on bean aphid, *Aphis fabae* Scop. Dusts containing chlordan[3] were made by impregnating pyrophyllite[4] with an acetone solution of chlordan, while nicotine alkaloid was mixed directly with pyrophyllite. Dust mixtures containing both chlordan and nicotine were obtained by mixing equal parts of chlordan and nicotine dusts of the same concentration. Each dust was applied over a turn-table[5] on nasturtium plants infested with bean aphids of various ages. The apparent mortality (Sun & Shepard 1947) was obtained as the difference between the numbers of living aphids before dusting and the numbers living one day after treatment. Four tests for each concentration of all dusts were made on the same day and this series was repeated three times. With the exception of 0.85 per cent chlordan, the averages were therefore based on twelve tests (Table 1).

When mortalities of aphids were plotted in probits and dust concentrations in lagarithms similar slopes were shown for nicotine and chlordan dusts (Fig. 1, lines I and II). The following calculations are based on Wadley's graphic method for the analysis of synergism. By reading at 50 per cent mortality from lines and I and II, 0.35 per cent nicotine is required to produce the same effect as 0.52 per cent chlordan, *i.e.*, nicotine is 1.49 times as toxic as chlordan or chlordan is only 0.673 times as toxic as nicotine. However, at the 90 per cent level 0.70 per cent nicotine appears to equal 1.00 per cent chlordan, *i.e.*, nicotine is 1.43 times as toxic as chlordan or chlordan is only 0.700 times as toxic as nicotine. The average equivalent value is 1.46 for nicotine and 0.687 for chlordan. The results of calculation and interpolated mortalities are listed in table 2. It shows that the

Table 1.—Joint action of dusts containing chlordan and nicotine against the bean aphid.

Toxicant Content of Dust		Number of Tests	Total Aphids Before Dusting	Average Apparent Per Cent Mortality, 1 Day
Nicotine, Per Cent	Chlordan, Per Cent			
0.25	—	12	1334	30.4
0.50	—	12	1349	68.7
0.75	—	12	1218	92.0
1.00	—	12	1365	98.1
—	0.50	12	1110	49.0
—	0.75	12	1162	69.8
—	0.85	9	999	84.3
—	1.00	12	1486	92.9
0.125	0.125	12	1270	23.2
0.25	0.25	12	1299	76.3
0.375	0.375	12	1445	88.0
0.50	0.50	12	1455	96.2

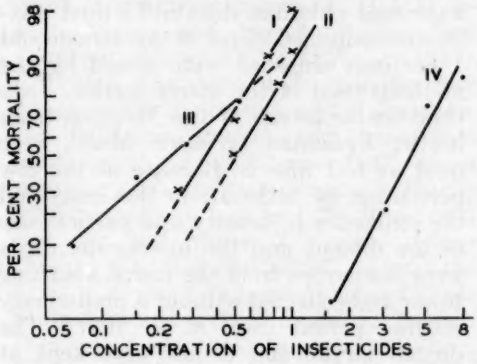

FIG. 1. Mortality curves obtained with nicotine (I) and chlordan (II) dusts (per cent) on bean aphids and with rotenone (III) and chlordan (IV) dusts (microgram of active ingredients per sq. cm.) on Mexican bean beetle larvae; plotted on log-probits scales.

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[2] Acknowledgement is made to Dr. H. H. Shepard for his valuable suggestions.

[3] Technical *Velsicol-1068;* Velsicol Corporation, Chicago, Ill.

[4] *Pyrax ABB;* R. T. Vanderbilt Co., New York, N. Y.

[5] Sun, Y. P., 1946. A preliminary study of the influence of *Velsicol AR-60* upon the insecticidal effectiveness of dusts containing rotenone or DDT. Dept. Ent., Cornell Univ., Ent. 1.

Table 2.—Actual and interpolated mortalities obtained with dust mixtures containing chlordan and nicotine.

Toxicant Content of Dust		Calculated Concentration of Dust		Mortality			Synergism
					Interpolated		
Nicotine Per Cent	Chlordan, Per Cent	Nicotine Equivalent, Per Cent	Chlordan Equivalent, Per Cent	Actual	As Nicotine	As Chlordan	
0.125	0.125	0.211	0.308	23.2	17.0	15.8	+
0.25	0.25	0.422	0.615	76.3	63.5	62.5	+
0.375	0.375	0.633	0.923	88.0	86.3	87.0	+
0.50	0.50	0.844	1.230	96.2	94.7	95.4	+

actual mortalities of the mixtures are slightly higher than the interpolated mortalities, either as nicotine or as chlordan. Hence mixtures of nicotine and chlordan tend to produce mortalities slightly exceeding those to be expected from similar joint action but the differences may not be great enough to prove synergistic action.

JOINT ACTION OF CHLORDAN AND ROTENONE.—In the study of the joint action of chlordan and rotenone, a 0.1 per cent rotenone dust was made by mixing cubé powder with pyrophyllite, while a 2 per cent chlordan dust and a dust mixture containing 0.05 per cent rotenone and 1 per cent chlordan were mixed by the methods used in the above section. Late third instar larvae of the Mexican bean beetle, *Epilachna varivestis* Muls., were used as test insects. Because of the low percentage of toxicants in the dusts and the difference in density and particle size of the diluent and the insecticide, dusts were discharged from the top of a settling tower and collected without a preliminary settling period (Sun *et al.* 1947). The dusted larvae and dishes were kept at 23° to 25° C. under high humidity. Only those larvae showing no signs of movement when prodded under light were counted as dead. Four-day mortality was used for comparison. To simplify the results, data obtained from each dust were divided, according to their range of deposit, into four groups, each containing the results obtained on different days. Corrected mortalities (Sun & Shepard, 1947) were plotted against the concentrations of active ingredients in probits-log scales (Table 3, Fig. 1, lines III and IV). The number of larvae represented by each point varies from 80 to 180 with an average of about 140. Since the slopes produced by chlordan and rotenone are quite different, the method used for the calculation of independent action was applied (Finney 1942). The actual mortality was significantly greater than the corresponding calculated mortality at each concentration. It appears that a mixture of chlordan and rotenone produce a joint action greater than the independent action.

Table 3.—Joint action of dusts containing chlordane and rotenone against third instar larvae of the Mexican bean beetle.

Toxicant Content of Dust		Active Ingredient of Dust Deposit Microgram per sq. cm.		Corrected Per Cent Mortality, 4 Days
Rotenone, Per Cent	Chlordan, Per Cent	Rotenone	Chlordan	
0.1	—	0.069	—	0.9
		0.149	—	37.7
		0.275	—	56.1
		0.521	—	77.4
—	2.0	—	1.60	1.8
		—	3.10	21.6
		—	5.16	74.9
		—	7.92	86.3
0.05	1.0	0.050	1.00	11.9
		0.095	1.90	43.6
		0.152	3.04	65.9
		0.196	3.91	89.0
Check, untreated				8.9

CONCLUSIONS AND SUMMARY.—Dust mixtures containing various concentrations and proportions of (1) chlordan and nicotine alkaloid, and (2) chlordan and rotenone were tested on the bean aphid and larvae of the Mexican bean beetle respectively. According to the loose definition of synergism, the addition of chlordan to either nicotine or rotenone produced a synergistic action. However,

on the basis of the usage of this term by Bliss (1939) and Finney (1942) and applying the graphic solution devised by Wadley (1945), chlordan-nicotine mixtures gave a joint action slightly greater than a similar joint action, while a chlordan-rotenone mixture gave a joint action greater than the independent action as determined by Finney's method (1942).

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Comparative Toxicity of Chlordan, DDT, Benzene Hexachloride and Chlorinated Camphene[1]

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Chlordan is a chlorinated hydrocarbon having the empirical formula $C_{10}H_6Cl_8$. Its principal composition is 1,2,4,5,6,7,8,8-octachloro-4,7-methano-3_a,4,7,7_a-tetrahydro indan (Annand 1947).

It has been reported that chlordan was more toxic than DDT to the spirea aphid, *Aphis spiraecola* Patch, pea aphid, *Macrosiphum pisi* (Kltb.), Colorado potato beetle (larvae), *Leptinotarsa decemlineata* (Say), squash bug, *Anasa tristis* (Deg.), house fly, *Musca domestica* L., American cockroach, *Periplaneta americana* (L.) (Kearns *et al.* 1945), pea leaf miner, *Liriomyza orbona* (Meig.) (Lange and Smith 1947) differential grasshopper, *Melanoplus differentialis* (Thos.) (Kearns *et al.* 1945, Weinman & Decker 1947, List & Hoerner 1947, Weinman *et al.* 1947), red-legged grasshopper, *M. femur-rubrum* (Deg.) (Weinman *et al.* 1947, List & Hoerner 1947), two-striped grasshopper, *M. bivittatus* (Say) List & Hoerner 1947), and lesser migratory grasshopper, *M. mexicanus mexicanus* (Sauss.) (Brown & Hurtig 1947); about as toxic as DDT to the common malaria mosquito (larvae), *Anopheles quadrimaculatus* Say (Kearns *et al.* 1945), and cucumber beetles, *Diabrotica duodecimpunctata* (F.) and *D. vittata* (F.) (Walton 1947); but less toxic than DDT to the greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), Japanese beetle, *Popillia japonica* Newm. (Langford & Squires 1947), honey bee, *Apis mellifera* L. (Eide 1947), codling moth, *Carpocapsa pomonella* (L.) Weinman 1947), and hawthorn lace bug, *Corythuca cydoniae* (Fitch), (Walton 1947). Chlordan was more toxic than benzene hexachloride to the differential grasshopper, red-legged grasshopper, two striped grasshopper (List & Hoerner 1947), lesser migratory grasshopper (Brown & Hurtig 1947), hawthorn lace bug (Walton 1947) and pea leaf miner, *Liriomyza orbona* (Meig.) (Lange & Smith 1947); about the same in toxicity as benzene hexachloride to the common malaria mosquito (larvae) (Kearns *et al.* 1945), and squash bug, (Walton 1947); but less toxic than benzene hexachloride to the greenhouse thrips (Metcalf 1947), differential grasshopper (Kearns *et al.* 1945, Brett & Rhoades 1946b, Weinman and Decker 1947), corn lantern fly, *Peregrinus maidis* (Ashm.), fall armyworm, *Laphygma frugiperda* (A. & S.), turnip aphid, *Rhopalosiphum pseudobrassicae* (Davis) (Brooks & Anderson 1947) and boll weevil, *Anthonomus grandis* Boh. (Brett & Rhoades 1947). With the exception of the results (based on benzene hexachloride containing 10 per cent of gamma isomer) obtained by List & Hoerner (1947), Brown & Hurtig (1947), and Walton (1947), all data on

[1] Research project supported by the Velsicol Corporation, Chicago, Ill.

benzene hexachloride were compared on the basis of the per cent of gamma isomer. This may explain the controversy of some of the above results. It was also found that chlordan controlled the red harvester ant, *Pogonomyrmex barbatus* var. *molefacians* (Buck) (Brett & Rhoades 1946a), more effectively than any material which has yet been tested and is the most promising material for several species of grasshoppers (Hinman & Cowan 1947).

The purpose of this research is to extend the study of the effectiveness of chlordan in comparison with DDT, benzene hexachloride and chlorinated camphene to other species of insects.

METHODS.—Insects used in the laboratory and greenhouse tests were reared in the greenhouse with the exception of the tarnished plant bug, spotted cucumber beetle, red-legged grasshopper and cricket which were obtained from field infestations. The benzene hexachloride dust was made from a commercial brand of wettable powder.[2] Dusts containing chlordan,[3] aerosol grade DDT,[4] technical DDT,[5] gamma isomer of benzene hexachloride[6] and chlorinated camphene[7] were impregnated on pyrophyllite[8] with acetone solution. Pyrophyllite was used as a dust diluent for all dust mixtures. To make 100 g. of a dust mixture, the required amount of an insecticide was first dissolved in 15 to 20 ml. acetone, and the solution was mixed in a mortar with a required amount of pyrophyllite so that the insecticide was impregnated on the diluent and the total weight was 100 g. without counting the weight of acetone. After thorough mixing and evaporation of the acetone, the dust mixture was transferred to a ball mill and again mixed for about one half of an hour.

In order to avoid possible variations in the susceptibility of insects from day to day, all insecticides to be compared were tested against a given species of insect on the same day. Laboratory tests were carried out by the following methods: (1) a dusting method described by Sun[9] was used by jarring down dusts from a small vial. The approximate amount of dusts, about 0.6 mg. per sq. cm., can be obtained by weighing the vial before and after dusting; (2) a dust settling tower method using an improved dust disperser (Sun *et al.* 1947); and (3) a spraying technique by which insects were passed twice through a cone of spray from a DeVilbiss gun[10] as described by Hansberry (Campbell & Moulton 1943). After treatment insects were placed for further observation in a constant temperature room maintained at 23° to 25°. Those insects showing no signs of movement on prodding were considered as dead. In the case of melon aphids which reproduced rapidly, the number of young produced after dusting or spraying but before the counting of mortality was also included in the mortality counts. Apparent or corrected mortality (Sun & Shepard 1947) was used to express the results on aphids and thrips in laboratory and greenhouse tests. Corrections were also made on other insects when the natural mortality in checks was available. In cases in which only adult aphids were taken into consideration, young aphids produced after treatment were not counted.

Two methods of insecticide application were used on potted plants in the greenhouse tests. Dusts were blown from a small bottle and directed at the plants as they rotated on the turn-table. This technique described more fully by Sun,[9] gave a complete and uniform coating on the plants by using about 12 grams of dust. Sprays were delivered by an air pressure of 15 pounds per square inch through a DeVilbiss gun at the rate of 70 ml. of diluted emulsion for six revolutions of the turn-table. The coverage was good on both sides of leaves without dripping. After dusting or spraying plants were kept in the greenhouse for several days. The difference between the number of insects immediately before application and each observation period after application was considered to be the mortality of the insects due to treatment and is converted to per cent control in table 2. In the cases of aphids and onion thrips negative values in untreated checks are due to net increases in population since reproduction was greater than the natural mortality.

Field experiments were generally car-

[2] *Gammaloid*, containing 5 per cent gamma isomer; American Cyanamid Company, New York, N. Y.
[3] Technical *Velsicol-1068;* Velsicol Corporation, Chicago, Ill.
[4] Setting point, about 104° C.; Hercules Powder Company, Wilmington, Del.
[5] Geigy Company, Inc., New York, N. Y.
[6] Melting point, about 110° C.
[7] *Toxaphene;* Hercules Powder Co.
[8] *Pyrax ABB;* R. T. Vanderbilt Company, New York, N. Y.
[9] Sun, Y. P. 1946. A preliminary study of the influence of *Velsicol AR-60* on the insecticidal effectiveness of dusts containing rotenone or DDT. Dept. Ent., Cornell Univ., Ent. 1.
[10] Type CH62201; The DeVilbiss Company, Toledo, Ohio.

Table 1.—Laboratory results on the relative toxicity of chlordane, DDT, benzene hexachloride, and chlorinated camphene.

Toxicant Content of Dust or Dilution	Dust Deposit, Mg. Per Sq. Cm.	Number of Tests	Number of Insects	Average Per Cent Mortality
Pea aphid, adults—40-hour corrected mortality				
Gamma-benzene hexachloride, 2%	0.63	2	50	93.3
Chlordan, 2%	0.48	2	50	86.6
DDT (aerosol grade), 2%	0.47	2	50	57.8
Chlorinated camphene, 2%	0.61	2	50	40.0
Check, untreated	—	2	50	10.0
Potato aphid, adults—1-day mortality				
Gamma-benzene hexachloride, 5%	0.51	2	50	98
Chlordan, 5%	0.45	2	50	96
DDT (aerosol grade), 5%	0.49	2	50	74
Chlorinated camphene, 5%	0.35	2	50	66
Melon aphid, various ages—1-day corrected mortality				
DDT (tech.),[1] 1:100	—	9	874	98.9
1:300	—	9	745	93.2
Chlordan,[1] 1:100	—	9	746	97.7
1:300	—	9	763	78.6
Check, untreated	—	9	778	−1.2
Red-legged grasshopper, nymphs and adults—2-day corrected mortality				
Chlordan, 0.05%	—	2	20	50.0
0.1 %	—	2	20	89.0
DDT (tech.), 1 %	—	3	30	18.5
3 %	—	5	50	13.3
Check, untreated	—	4	18	10.0
Cricket, nymphs and adults—2-day corrected mortality				
Chlordan, 0.05%	—	5	50	88.4
0.1 %	—	5	50	100.0
DDT (tech.), 0.5 %	—	4	40	50.9
1 %	—	3	30	84.7
Check, untreated	—	3	15	13.3
Greenhouse white fly, adults—1-day corrected mortality				
Gamma-benzene hexachloride, 1%	0.13	2	160	97.8
DDT (aerosol grade), 1%	0.16	2	169	85.6
Chlordan, 1%	0.92	2	92	52.6
Check, untreated	—	2	88	0
Tarnished plant bug, adults—2-day mortality				
Chlordan, 1%	—	3	27	95.8
DDT (aerosol grade), 3%	—	2	19	54.0
Mexican bean beetle, adults—4-day corrected mortality				
DDT (aerosol grade), 5%	0.54	4	80	6.2
Chlordan, 5%	0.47	4	80	5.0
Gamma-benzene hexachloride, 5%	0.54	4	80	3.8
Chlorinated camphene, 5%	0.47	4	80	0
Check, untreated	—	2	40	0
Mexican bean beetle, 3rd. instar larvae—4-day mortality				
Chlordan, 2%	0.27	2	50	84
DDT (aerosol grade), 2%	0.37	2	50	44
Colorado potato beetle, adults—4-day corrected mortality				
Chlordan, 1%	—	6	60	78.3
DDT (aerosol grade), 1%	—	6	60	70.0
Check, untreated	—	3	30	0
Colorado potato beetle, last instar larvae—4-day corrected mortality				
DDT (aerosol grade), 1%	23.9	3	30	51.9
Chlordan, 1%	23.8	3	30	14.7
Check, untreated	—	2	20	10.0
Spotted cucumber beetle, adults—4-day corrected mortality				
Chlordan, 0.5%	—	3	69	100
DDT (tech.), 0.5%	—	3	73	97.3
Check, untreated	—	2	16	0
Southern armyworm, medium larvae—2-day mortality				
DDT (aerosol grade), 1%	0.53	3	30	100
Gamma-benzene hexachloride, 1%	0.54	3	30	100
Chlordan, 1%	0.51	3	30	96.7
Nicotine, 1%	0.51	3	30	0
Imported cabbageworm, last instar larvae—2-day corrected mortality				
DDT (tech.), 3%	—	10	100	79.2
Chlordan, 3%	—	10	100	5.6
Check, untreated	—	9	90	8.9

[1] An emulsion concentrate containing 20 g. insecticide (DDT or chlordan), 30 ml. *Velsicol AR-50*[2], 46 to 47 ml. kerosene, and 10 ml. *Atlox G1045A*[3] (emulsifier). The final volume is 100 ml.

[2] Mainly methylnaphthalenes with a distillation range from 440° to 525° F.; Velsicol Corporation, Chicago, Ill.

[3] A polyoxyethylene sorbitol mixed fatty acid ester; Atlas Powder Company, Wilmington, Del.

ried out on small plots arranged at random and treated with a rotary hand duster or a knapsack sprayer. The methods used in expressing the per cent of control varied and will be stated under each field experiment.

RESULTS. *Aphids.*—Laboratory results (table 1) show that 2 and 5 per cent chlordan dusts gave higher mortalities than DDT and chlorinated camphene of the same concentrations on adults of the pea aphid, *Macrosiphum pisi* (Kltb.), and potato aphid, *M. solanifolii* (Ashm.). At a dilution of 1 to 300 of an emulsion concentrate containing 20 g. insecticide per 100 ml., chlordan was slightly less toxic than DDT to the melon aphid, *Aphis gossypii* Glov., of various ages.

In greenhouse and field experiments aphids of various ages were included in the mortality counts. The results show that chlordan was less effective than DDT against the pea aphid (Tables 2 and 3) and potato aphid (Table 2), but more effective against the bean aphid, and green peach aphid, *Myzus persicae* (Sulz.) (Table 2). Based on equal concentrations gamma-benzene hexachloride appears to be more potent than the other insecticides tested.

Red-legged grasshopper.—On the basis of the actual death of insects both laboratory (Table 1) and field cage (Table 3) tests indicate that chlordan was highly toxic to nymphs and adults of the red-legged grasshopper, *Melanoplus femur-rubrum* (Deg.). A 0.1 per cent chlordan dust gave 89.0 per cent mortality, while a 3 per cent DDT dust only 13.3 per cent (Table 1). In field cage tests, a 1 per cent chlordan dust was nearly as effective as gamma-benzene hexachloride of the same concentration, but the latter acted faster (Table 3). The time required for the first grasshopper to be paralyzed by gamma-benzene hexachloride was about 90 min-

Table 2.—Greenhouse results on the relative toxicity of chlordane, DDT, benzene hexachloride, and chlorinated camphene.

Toxicant Content of Dust or Dilution	Number of Tests	Number of Insects	Average Per Cent Mortality 1 Day	3 Days
Bean aphid, various ages—apparent mortality				
Gamma-benzene hexachloride, 1%	6	787	100	100
Chlordan, 1%	6	749	92.6	99.5
Chlorinated camphene, 1%	6	739	70.7	98.2
DDT (aerosol grade), 1%	6	835	7.5	89.2
Potato aphid, various ages—corrected mortality				
DDT (tech.), 1%	6	574	77.4	93.7
5%	6	551	93.9	98.3
Chlordan, 1%	6	607	60.3	91.6
5%	6	675	89.5	100
Check, untreated	6	625	−31.9	−114
DDT (tech.),[1] 1:400	6	803	93.5	99.8
1:800	3	430	88.2	94.7
Chlordan,[1] 1:100	6	773	90.9	99.6
1:200	6	645	80.6	98.7
Check, untreated	6	803	+34.2	−118.3
Pea aphid, various ages—corrected mortality				
DDT (tech.), 1%	3	321	95.8	99.3
Chlordan, 3%	3	436	94.7	99.5
Check, untreated	3	459	−72.4	−153.0
Green peach aphid, various ages—corrected mortality				
Chlordan, 1%	3	262	88.8	—
DDT (tech.), 1%	3	680	67.4	—
3%	3	676	77.6	—
Check, untreated	1	42	−23.8	—
Striped flea beetle, adults—corrected mortality				
Chlordan, 1%	3	66	100	—
DDT (tech.), 1%	3	64	96.6	—
Check, untreated	1	22	8.7	—
Mexican bean beetle, 3rd. instar larvae—2- and 4-day mortality				
Gamma-benzene hexachloride, 2%	6	60	95.0	100
Chlordan, 2%	6	60	93.3	95.0
Chlorinated camphene, 2%	6	60	85.0	96.7
DDT (aerosol grade), 2%	6	60	48.3	78.3
Colorado potato beetle, adults—2- and 4-day corrected mortality				
Chlordan, 1%	6	60	91.7	98.2
DDT (aerosol grade), 1%	6	60	66.7	93.0
Check, untreated	2	20	0	5.0
Colorado potato beetle, last instar larvae—2- and 4-day mortality				
DDT (aerosol grade), 1%	3	30	100	—
Chlordan, 1%	3	30	100	—
Spotted cucumber beetle, adults—2- and 4-day corrected mortality				
DDT (tech.), 1%	6	72	83.3	100
Chlordan, 3%	3	36	75.0	97.7
Check, untreated	5	60	0	0
Onion thrip, various ages—corrected mortality				
Gamma-benzene hexachloride, 2%	3	90	98.8	100
Chlordan, 2%	3	109	97.0	100
DDT (aerosol grade), 2%	3	99	94.8	100
Check, untreated	4	61	−37.2	−819

[1] The same formulation as used in table 1.

utes, while it took about 210 minutes for chlordan to produce the same effect.

Crickets.—It was found in the laboratory that crickets, *Nemobius fasciatus* Deg., were more susceptible to chlordan than to DDT. A 0.05 per cent chlordan dust killed 88.4 per cent of crickets in 2 days, while a 1 per cent DDT dust gave only 84.7 per cent mortality (Table 1).

Greenhouse whitefly.—Laboratory results show that at 1 per cent level chlordan was less toxic than either DDT or gamma-benzene hexachloride to the greenhouse whitefly, *Trialeurodes vaporariorum* (Westw.) (Table 1).

Onion thrips.—When tested on potted onion plants in the greenhouse, dust mixtures containing 2 per cent chlordan, DDT or gamma-benzene hexachloride gave excellent controls on the onion thrips, *Thrips tabaci* Lind. (Table 2). Control was too high with the concentration tested to show much difference between materials.

Mexican bean beetle.—Although dust mixtures containing 2 per cent of gamma-benzene hexachloride, chlordan, chlorinated camphene or DDT gave good controls on third instar larvae of the Mexican bean beetle, *Epilachna varivestis* Muls., in greenhouse tests (Table 2), the results obtained from a 3 per cent DDT or chlordan dust in the field were not encouraging (Table 3). As shown in laboratory tests DDT was less effective than chlordan. All the above dusts containing 5 per cent toxicant gave poor results on the adults (Table 1).

Spotted cucumber beetle.—In laboratory tests a 0.5 per cent chlordan dust was more toxic than a 0.5 per cent DDT dust to adults of the spotted cucumber beetle, *Diabrotica duodecimpunctata* (F.) (Table 1), but greenhouse results indicate that 3 per cent chlordan was not quite as effective as 1 per cent DDT (Table 2).

Southern armyworm.—At 1 per cent concentration DDT, gamma-benzene hexachloride and chlordan were very toxic to medium larvae (0.10 g. each) of the southern armyworm, *Prodenia eridania* (Cram.), while a 1 per cent nicotine dust did not give any mortality in two days (Table 1).

Potato insects.—Preliminary laboratory tests revealed that a 1 per cent chlordan dust gave a much higher mortality than a 3 per cent DDT dust on the tarnished plant bug, *Lygus oblineatus* (Say) (Table 1).

When compared with the population of the check, field experiments indicate that at 1 to 500 dilution of an emulsion concentrate containing 20 g. insecticide in 100 ml., DDT gave a slightly better control than chlordan on the potato flea beetle, *Epitrix cucumeris* (Harr.), but was

Table 3.—Field results on the relative toxicity of chlordane, DDT, and rotenone.

TOXICANT CONTENT OF DUST OR DILUTION	NUMBER OF TESTS	NUMBER OF INSECTS	AVERAGE PER CENT CONTROL 3 DAYS
Pea aphids, various ages—5-day counts			
DDT (tech.), 3%	2	33.5 (per 20 tips)	97.4
Chlordan, 3%	2	958	25.9
Check, untreated	2	1290	—
Red-legged grasshopper, nymphs and adults—4-day counts			
Gamma-benzene hexachloride, 1%	4	80	93.8
Chlordan, 1%	4	80	91.3
DDT (tech.), 1%	2	40	27.5
Potato flea beetle, adults			
DDT (tech.),[1] 1:500	2	1 (per 50 leaves)	98.1
Chlordan,[1] 1:500	2	5.5	90.2
Check, untreated	4	57.3	—
Potato leaf-hopper, nymphs and adults			
DDT (tech.), 0.5%	3	3.3 (per 50 leaves)	94.7
Chlordan, 3%	3	27.7	50.6
Check, untreated	3	56.0	—
DDT (tech.),[1] 1:500	2	0 (per 50 leaves)	100
Chlordan,[1] 1:500	2	55.5	22.3
Check, untreated	4	71.5	—
Imported cabbageworm, larvae			
Rotenone, 0.25% & chlordan, 1%	9	148	85.1
Rotenone, 0.75%	9	141	82.4
DDT (tech.), 3%	9	86	79.5
DDT (tech.), 1%	9	102	76.9
Rotenone, 0.5% & *Velsicol AR-60*,[2] 3%	9	104	70.3
Chlordane, 3%	9	136	59.4
Cabbage looper, larvae			
DDT (tech.), 1%	9	20	94.1
Rotenone, 0.75%	9	62	63.1
Chlordan, 3%	9	37	62.6
Rotenone, 0.25% & chlordan, 1%	9	52	52.7
Rotenone, 0.5% & *Velsicol AR-60*,[2] 3%	9	48	44.0
Striped flea beetle, adults			
DDT (tech.), 1%	6	265	100
Rotenone, 0.75%	6	219	100
Rotenone, 0.25% & chlordan, 1%	6	256	100
Rotenone, 0.5% & *Velsicol AR-60*,[2] 3%	6	296	100
Chlordan, 1%	6	381	97.2
Mexican bean beetle, 3rd. & 4th. instar larvae			
DDT (tech.), 1%	3	90	18.9
3%	3	90	65.5
Chlordan, 1%	3	90	43.4
3%	3	90	51.1
Check, untreated	3	90	18.9
Colorado potato beetle, adults—2-day counts			
Chlordan, 1%	2	60	88.4
Colorado potato beetle, 3rd. & 4th. instar larvae—2-day counts			
Chlordan, 1%	1	103	100

[1] The same formulation as used in table 1.
[2] Mainly methylnaphthalenes, with a distillation range from 460° to 565° F.; Velsicol Corporation, Chicago, Ill.

much better than chlordan on the potato leafhopper, *Empoasca fabae* (Harr.). When compared as dusts on leafhoppers, 3 per cent chlordan was inferior to 0.5 per cent DDT (Table 3). It appears that chlordan is effective against the potato flea beetle but not against the potato leafhopper.

At one per cent level, chlordan was slightly more toxic in laboratory tests than DDT to adults of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say), but less toxic to the last instar larvae (Table 1). The greenhouse results indicate that a 1 per cent chlordan dust was more effective than DDT of the same concentration against adults, and both materials were very effective against the last instar larvae (Table 2). Because of limited field infestations only chlordan was tested in the field. On the basis of the reduction in population before and after treatment a 1 per cent chlordan dust gave very good results on both adults and larvae (Table 3).

Cabbage insects.—Laboratory results show that a 3 per cent DDT dust was fairly toxic to last instar larvae of the imported cabbageworm, *Pieris rapae* (L.), while a 3 per cent chlordan dust gave only a low mortality (Table 1).

One per cent dust of chlordan or DDT was very effective against the striped flea beetle, *Phyllotreta vittata* (F.), in greenhouse tests, and chlordan was slightly more effective than DDT (Table 2).

Field results were based on the population counts made before and after treatment. Both DDT and chlordan dusts at 1 per cent concentration gave good controls on the striped flea beetle, but chlordan alone was not as good as DDT on the imported cabbageworm and cabbage looper, *Trichoplusia ni* (Hbn.). However a dust mixture containing 0.25 per cent rotenone and 1 per cent chlordan gave a better control than 3 per cent DDT and other treatments. DDT was far better than other treatments on the cabbage looper (Table 3). In those plots treated with 3 per cent DDT the aphid damage was heavier than in those treated with 3 per cent chlordan or other combinations of insecticides. Plots treated with 1 per cent DDT gave good controls on cabbageworms, and showed much less aphid damage as compared with 3 per cent DDT.

Cabbage maggot.—The relative protection of chlordan, DDT and benzene hexachloride (wettable powder) given to the radish against the cabbage maggot, *Hylemya brassicae* (Bouche), was compared as follows: (1) by soil treatment

with 5 per cent dusts, (2) by pouring 5 per cent dust suspensions on the soil around the plants, and (3) by pouring emulsions containing 0.2 per cent toxicant on the soil around the plants. It was found that by the method of soil treatment seed germination was only 3.2 per cent for benzene hexachloride (containing 5 per cent gamma isomer), and 64.0, 48.2, and 62.4 per cent respectively for DDT, chlordan, and check. In treatments with dust suspensions over 90 per cent of young plants were killed by benzene hexachloride one day after the first application, but none was hurt by DDT or chlordan. For all three treatments chlordan always gave a somewhat better protection than DDT.

CONCLUSIONS AND SUMMARY.—Chlordan is effective against most of 20 species of insects tested in laboratory, greenhouse, and field experiments. Good controls were obtained on the red-legged grasshopper, cricket, potato flea beetle, striped flea beetle, Colorado potato beetle, tarnished plant bug, southern armyworm, bean aphid, potato aphid, green peach aphid, and onion thrips. The comparative toxicity of chlordan, DDT, gamma-benzene hexachloride, and other insecticides is summarized as follows: On the basis of laboratory results chlordan was more toxic than DDT to the adult pea aphid, potato aphid, red-legged grasshopper, cricket, tarnished plant bug, Mexican bean beetle larva; about the same in toxicity to the Colorado potato beetle adult, southern armyworm, and spotted cucumber beetle; but less toxic than DDT to the melon aphid, greenhouse whitefly, Colorado potato beetle larva, and imported cabbageworm. Chlordan was approximately the same in toxicity as gamma-benzene hexachloride to the potato aphid, adult pea aphid, and southern armyworm; but less toxic to the greenhouse whitefly. As compared with chlorinated camphene, chlordan was more toxic to the adult pea aphid. It is interesting to know that Mexican bean beetle adults were very resistant to dust mixtures containing 5 per cent chlordan, DDT, gamma-benzene hexachloride or chlorinated camphene.

The results of greenhouse tests show that chlordan was more effective than DDT against the bean aphid, green peach aphid and Mexican bean beetle larva; approximately the same in effectiveness against the potato aphid, striped flea beetle, Colorado potato beetle (adult and larva) and onion thrips; but less effective against the pea aphid and spotted cucumber beetle. As compared with gamma-benzene hexachloride, chlordan was of the same order of effectiveness against the Mexican bean beetle larva and onion thrips; but slightly less effective against the bean aphid. Chlordan was about as effective as chlorinated camphene against the bean aphid and Mexican bean beetle larva.

Field results indicate that chlordan was more effective than DDT against the red-legged grasshopper and cabbage maggot; nearly the same in effectiveness against the potato flea beetle, and Mexican bean beetle larva; but less effective against the pea aphid, potato leafhopper, imported cabbageworm and cabbage looper. A dust mixture containing 0.25 per cent rotenone and 1 per cent chlordan gave a better control than 3 per cent DDT and other treatments on the imported cabbageworm, but was less satisfactory than DDT on the cabbage looper. In field cage tests chlordan was nearly as toxic as gamma-benzene hexachloride to the red-legged grasshopper.

In some cases great differences were observed between laboratory and field results. For example, a 2 per cent chlordan dust was quite toxic to the pea aphid in laboratory tests, but a 3 per cent chlordan dust was rather ineffective against the same insect in the field. In another case, 1 per cent chlordan gave rather poor results in the laboratory on larvae of the Colorado potato beetle, but a complete control was obtained in the field with the same dust. Such variations, as indicated in this and previous papers, may be due to the rate of volatility and decomposition of insecticides (Sun, unpublished data), the differences in the mode of action of insecticides (Sun & Hansberry 1947), the rate of reproduction,[9] the relative resistance of insects of various ages (Sun & Shepard 1947), the environmental conditions,[9] the criteria of death, the methods of expressing mortality (Sun & Shepard 1947), etc.

As compared with the results in the literature on the same insect species under comparable conditions, the same order of

toxicity for chlordan and DDT was obtained on the pea aphid, spotted cucumber beetle (Kearns *et al.* 1945), and red-legged grasshopper (Weinman *et al.* 1947), but not on larvae of the Colorado potato beetle (Kearns *et al.* 1945).—12-18-47

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PACIFIC NORTHWEST VEGETABLE INSECT CONFERENCE

The seventh annual conference was held in the Multnomah Hotel, Portland, Oregon on January 19 and 20, 1948, under the chairmanship of Joseph C. Chamberlin. The first day was devoted to discussions of pea insects (William C. Cook, leader), potato insects (S. E. Crumb, leader), wireworms, white grubs, nematodes (M. C. Lane, leader), cole crop insects, lettuce insects, onion insects, carrot insects, corn insects (Paul Eide, leader). After an entomologists' dinner on the evening of the first day, the morning of the second day was devoted to insects of small fruits (R. L. Rosentiel, leader). During the afternoon of the second day, an open meeting was held to which commercial entomologists were invited. At this session 1947 research was reviewed and talks were given on the role of commercial entomologists and of federal and state entomologists in insect control work. There was also a discussion of insecticides and equipment. The two-day program was arranged by David H. Brannon, Secretary.

Cabbage Maggot Insecticidal Tests[1]

L. E. Dills and M. L. Odland,[2] *Pennsylvania Agricultural Experiment Station, State College*

The cabbage maggot, *Hylemya brassicae* (Bouché), often causes serious injury to cabbage, cauliflower, radish and related crops. Most of the damage in Pennsylvania is reported from early plantings but infestations may be found later in the season, especially on turnips and rutabagas.

Repeated trials have shown the value of mercuric chloride and mercurous chloride in reducing injury but they have not been as widely used by growers as might be expected. The chief objections have been cost of application, high price of the materials, and shortage of mercury during the war emergency. For these reasons field experiments to find more satisfactory and more readily available materials were conducted at this station in 1943, 1944, 1946 and 1947. Only the results obtained in 1943 have previously been reported (Dills *et al.* 1944).

Methods—*Radish.* Preliminary work indicated that the toxicity of insecticides to this insect can be more easily and accurately measured by using radishes than by using cabbage. Therefore all preliminary trials were made on radishes and the more promising materials were later used on cabbage. The only disadvantage experienced in using radishes as the host plant in the tests is that a number of materials which cause injury to radishes may be used with safety on cabbage. Prior to 1947, White Icicle radishes were used but since this variety was found to be very susceptible to disease, especially during wet weather, the Scarlet Globe variety was used in 1947.

Including the check, 31 treatments were applied to radishes in 1946. The plots were in an incomplete block arrangement (Weiss & Cox 1939) with six replications. In 1947 there were 36 treatments including the check or untreated and the plots were arranged in a lattice design (Cox *et al.* 1940) with six replications. Each plot consisted of 10 feet of row. The materials were applied as solutions, emulsions or suspensions, 1.25 liters being used to a plot. Sodium lauryl sulfate was used with insoluble materials which did not readily suspend or disperse in water. The application was made by pouring the liquid on the young plants in the row, soon after the second pair of true leaves had begun to develop. Except for mercuric chloride and dichloroethyl ether, where both one and two treatments were used, the plots received only one application. When a second treatment was applied it was made 11 days after the first in 1946 and 8 days after the first in 1947.

Counts were made by slicing all sizable radishes in a plot and determining the percentage infested. Since the infestation was light in 1946, no counts were made on the plots treated with lower concentrations if the higher concentrations showed little or no insect toxicity. In 1947 counts were made in all plots.

The amount of injury to the radish plants was determined several times during the first 5 days after the insecticides were applied. The scale was slight, moderate, severe and dead. Plus or minus indicates slightly more or less than the rating given.

Cabbage.—Marian Market cabbage was used in 1944 with the plots arranged in a 6 by 6 latin square. Each plot consisted of 20 plants. Golden Acre cabbage was used in 1947 and the plots were arranged in a 9 by 9 latin square with an average of almost 16 plants to a plot. Several days after the plants had been set the materials to be tested were applied as dusts. Bentonite was used as the diluent in treating the Marian Market cabbage and pyrophyllite was used with Golden Acre. Mercurous chloride and benzene hexachloride were mechanical mixtures of the toxicant with the diluent. The pyridine sulfates and tar oil were impregnated dusts. The application was made with a 2-quart plunger type duster and several puffs were given at the base of each plant. No record of the amount of dust used in 1944 was kept, but by weighing the dust before and after the application in 1947 it was found that each cabbage plant was treated with an average

[1] Authorized for publication on October 27, 1947 as paper No. 1400 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

[2] Assistant Professor of Economic Entomology and Professor of Olericulture, respectively.

of slightly more than 1 gram of dust and that the rate of application was 23 pounds of dust to an acre.

In 1944, yield records on cabbage were taken but this could not be done in 1947 as the plots consisted of the nine buffer rows in a fertilizer experiment and they had not received equal amounts of fertilizer. Therefore on June 12 the plants were removed and the amount of maggot damage was recorded. A few of the plants treated with the different concentrations of benzene hexachloride were allowed to develop so as to determine whether or not any objectionable flavor was present.

MATERIALS

4-*n*-Amylpyridine.
Benzene hexachloride—1946, 31.6 per cent benzene hexachloride containing 12 per cent gamma isomer; 1947, 50 per cent benzene hexachloride containing 12 per cent gamma isomer.
Chlordan—50 per cent wettable powder.
Chlorinated camphene—50 per cent miscible concentrate.
Cupric dinicotinammino fumarate decahydrate
1,1-dichloro-2,2-bis(*p*-chlorophenyl) ethane, in a 25 per cent emulsion.
DDT—25 per cent miscible concentrate.
Dichloroethyl ether.
Dicyclohexylamine salt of dinitro-*o*-cyclohexylphenol—20 per cent wettable powder.
2,4-Diiodoaniline.
2-Ethylpyridine sulfate.
Hexaethyl tetraphosphate.
2-*n*-Hexylpyridine sulfate.
Mercuric chloride—U.S.P.
Mercurous chloride—U.S.P.
2-Mercapto-6-nitrobenzothiazole.
Methoxy analog of DDT or 1,1,1-trichloro-2,2-bis (*p*-methoxyphenyl) ethane—50 per cent wettable powder.
4-(5-Nonyl)pyridine.
Pyrenone dust base containing 2.5 per cent piperonyl cyclohexenone and .2 per cent pyrethrins.
Ryania—100 per cent ground *Ryania* stems.
Sabadilla—50 per cent sabadilla seed concentrate.
Sodium lauryl sulfate granules.
Tar oil.
Tetraethyl pyrophosphate.

RESULTS.—*Radishes.* The treatments for 1946 reported in table 1 were applied when the ground was quite damp and the applications were followed by excessively wet weather which undoubtedly reduced the effectiveness of some of the materials. In spite of these unfavorable conditions a few conclusions can be made and those which were corroborated by the results of the following year are especially significant.

Under the conditions of this experiment the most toxic material used in 1946 was benzene hexachloride which was found to be highly effective in the control of this insect at all concentrations used. DDT was somewhat toxic. The results show that the dicyclohexylamine salt of dinitro-*o*-cyclohexylphenol is toxic to the cabbage maggot but its high phytotoxicity makes it undesirable as an insecticide.

The excessively wet weather immediately following treatment probably reduced the effectiveness of the mercuric chloride and this, with the high moisture content of the soil at the time of treatment, may be the reason for the very poor results with dichloroethyl ether. Under drier conditions dichloroethyl ether had previously (Dills, *et al.* 1944) shown considerable promise.

The pyridine bases were tested because in 1943 several of their sulfates had shown marked toxicity to the cabbage maggot. Sodium lauryl sulfate which was used as the emulsifier gave a quick breaking emulsion which made it difficult to apply the toxicant uniformly. This no doubt is at least partly responsible for the plant injury from the two pyridines.

At the concentrations used and under the conditions of the experiment, cupric dinicotinammino fumarate decahydrate, 2-mercapto-6-nitrobenzothiazole and sabadilla seed were all found to be ineffective.

In 1947 conditions were favorable for the cabbage maggot and a heavy infestation occurred in the radish plots. The results are given in table 2. As in 1946 benzene hexachloride was found to be highly toxic and in this experiment was exceeded only by chlordan which gave the best results of the materials tested. Chlorinated camphene was also found to be highly toxic to this insect. The results with DDT corroborate the tests of the previous year in showing that this material has some toxicity to cabbage maggots. DDD was found to be equally effective to DDT. Under the conditions of this experiment, these two materials were approximately equal to mercuric chloride which was used as the standard treatment. The table also shows that 2,4-diiodoaniline, the methoxy analog of DDT, hexaethyl tetraphosphate, tetraethyl pyrophosphate, pyrenone dust base, *Ryania* and sabadilla had little or no toxicity to the cabbage maggot at the

Table 1.—Results of insecticide tests on cabbage maggots in radishes, 1946.

Insecticide	Concentration	Plant Injury	Radishes Examined	Average Infestation	Sum of Equivalent Angles
	Per Cent	*Degree*	*Number*	*Per Cent*	
Benzene hexachloride	.53	Slight+	227	.6	10.78
	.26	Slight	384	.6	15.71
	.13	None	269	0	0
	.07	None	333	1.5	27.88
DDT	.4	Slight−	294	1.1	25.31
	.2	None	357	2.4	47.20
	.1	None	327	5.9	79.97
	.05	None	323	5.9	74.40
Dicyclohexylamine salt of dinitro-*o*-cyclohexylphenol	.1	Severe−	116	0	0
" " "	.05	Moderate	168	4.0	46.83
Mercuric chloride	.1	Slight−	289	3.4	49.25
Mercuric chloride (2 treatments)	.1	Slight	312	2.1	33.85
Dichloroethyl ether+sodium lauryl sulfate .05%	.2	None	375	5.7	78.35
Dichloroethyl ether+sodium lauryl sulfate .05% (2 treatments)	.2	None	323	6.7	78.98
4-*n*-Amylpyridine+sodium lauryl sulfate .05%	.2	Moderate	311	7.7	94.79
4-(5-Nonyl)pyridine+sodium lauryl sulfate .05%	.2	Moderate+	263	8.9	92.42
Cupric dinicotinammino fumarate decahydrate+sodium lauryl sulfate .05%	.4	Slight	353	5.8	75.50
" " "	.1	Slight−	485	8.5	97.97
2-Mercapto-6-nitrobenzothiazole +sodium lauryl sulfate .05%	.8	None	397	10.0	95.25
Sabadilla Seed	.8	None	432	6.2	78.37
No treatment	—	None	335	6.1	81.42
Difference required for significance at 5% level				42.06	
Difference required for significance at 1% level				55.67	

concentrations used. The pyrenone dust base, the *Ryania* and the sabadilla were preparations from the previous season and it is possible some deterioration may have taken place. But is also should be mentioned that a fresh preparation of sabadilla had been used in the previous season and the results showed that it had no toxicity.

Cabbage.—The results with Marian Market cabbage for 1944 are given in table 3. Due to a light infestation the calomel treatments not only gave yields similar to the check but the heads of the cabbages so treated developed at about the same time as the checks. In the pyridine plots the heads developed slightly earlier and the yields were higher but only those treated with 2-ethyl pyridine sulfate yielded significantly more than the untreated plots. No deleterious effect on the plants treated with the pyridine derivatives was observed. This is of interest because these materials had been found in the previous year to be quite toxic to cabbage maggot on radishes but moderate to very severe plant injury had resulted. The tar oil dusted plots gave total yields similar to those from the untreated plots but the crop was slightly delayed suggesting that there may have been some injurious effect on the cabbage plants from the tar oil. This same dust had given excellent results with maggots on radishes the previous year but was accompanied by very severe plant injury.

A comparison of mercurous chloride and benzene hexachloride used as dusts is given in table 4. Much variability occurred between replicates. This variation was at least partly due to the limited number of plants in each plot. In spite of this, the results show that in this experiment benzene hexachloride was superior to mercurous chloride. The plants in the benzene hexachloride plots that had been left for determination of the possibility of objectionable flavor were

Table 2.—Results of cabbage maggot control tests with Scarlet Globe radishes, 1947.

Insecticide		Plant Injury	Plants Examined	Average Infestation	Sum of Equivalent Angles
		Degree	*Number*	*Per cent*	
Benzene hexachloride	0.4%	Slight-	388	2.1	39.52
	.2	None	425	2.1	49.61
	.1	None	475	6.8	86.88
	.05	None	433	13.8	123.74
	.025	None	430	22.4	168.50
Chlordan	0.4	Slight	438	1.8	32.28
	.2	Slight-	469	1.1	24.60
	.1	None	397	4.0	61.56
	.05	None	461	6.4	84.17
Chlorinated camphene	0.4	None	406	6.9	86.58
	.2	None	483	11.8	114.16
	.1	None	429	12.2	118.74
	.05	None	453	17.3	145.45
DDT	0.4	Slight-	328	9.5	103.32
	.2	None	382	15.2	134.29
	.1	None	430	32.4	207.07
DDD	.2	None	375	18.0	149.82
	.1	None	369	30.5	199.37
	.05	None	463	48.4	264.43
Mercuric chloride	0.1	Slight-	381	30.5	199.52
Mercuric chloride (2 treatments)	.1	Slight	350	27.9	190.39
Mercuric chloride	.05	None	382	35.9	220.19
2,4-Diiodoaniline	0.2	None	335	46.6	258.27
Methoxy analog of DDT	0.4	None	424	47.8	262.26
	.2	None	375	50.5	271.73
	.1	None	384	56.1	291.11
	.05	None	397	55.6	289.81
Hexaethyl tetraphosphate	0.4	None	391	48.0	263.02
	.2	None	446	51.9	276.92
	.1	None	388	52.3	278.86
Tetraethyl pyrophosphate	0.4	Slight-	388	49.2	267.07
	.2	None	412	48.5	264.80
Pyrenone dust base	0.4	None	416	52.0	276.95
Ryania	0.4	None	423	50.5	271.57
Sabadilla seed+sodium lauryl sulfate .1%	0.4	None	404	49.7	269.02
Untreated	—	None	401	52.4	278.78
Difference required for significance at 5% level					37.64
Difference required for significance at 1% level					49.68

Table 3.—Yields of Marian Market cabbage in maggot tests, 1944.

Insecticide		Marketable Cabbage per 60 Plants
		Pounds
2-Ethylpyridine sulfate	10%	92.8
2-*n*-Hexylpyridine	10	85.4
Tar oil	10	62.4
Mercurous chloride	4	76.6
Mercurous chloride	10	71.7
Untreated	—	64.4
Difference required for significance at 5% level		24.9
Difference required for significance at 1% level		33.7

Table 4.—Results of insecticide tests on cabbage maggots in cabbage, 1947.

Treatment		Plants Examined	Average Infestation	Sum of Equivalent Angles
Mercurous chloride	1.0%	132	69.2%	515.17
	2.0	137	62.9	475.64
	4.0	131	58.6	449.43
	8.0	133	46.0	383.85
Benzene hexachloride	1.0	135	63.0	475.14
	2.0	135	53.5	409.29
	4.0	134	36.2	327.15
	8.0	124	15.6	169.05
Untreated	—	131	80.1	590.72
Difference required for significance at 5% level				104.70
Difference required for significance at 1% level				139.12

eaten by 47 different persons either raw or cooked. All reported that no objectionable flavor could be detected.

SUMMARY.—Additional plot tests to determine the toxicity of 23 different compounds to cabbage maggot have been made. Most of these materials were tested on radishes at several different concentrations and some of them in several different experiments. The most toxic compounds used were chlordan and benzene hexachloride. A chlorinated camphene was also found to be highly toxic. Several of the other compounds showed considerable toxicity to this insect. The phytotoxicity of these materials was also determined. A few were selected for more extensive tests on cabbage. Several of these which had previously been found to be quite toxic to cabbage maggot but had caused severe injury to radishes were found to have no deleterious effect on cabbage. When applied as a dust to cabbage, benzene hexachloride was found to be superior to mercurous chloride in preventing damage from cabbage maggot.—10-30-47.

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SCIENTIFIC NOTES

United States Records of *Typhlodromus mariposus* (Fox) from Rats in Florida[1]

D. C. Thurman, Jr.[2] and Nina Branch[3]

Early in 1946, specimens of a mite new to us occurred among ectoparasites collected from rats in Tampa, Florida. One specimen of this mite was forwarded to Dr. Irving Fox who confirmed our belief that it belonged to the genus *Borinquolaelaps* which he recently had described (1946) from rats in Puerto Rico and that it represented the species *B. mariposus* Fox. Subsequently Dr. E. W. Baker of the U. S. Department of Agriculture (in lit.) has informed us that this species belongs in the genus *Typhlodromus* Scheuten 1857. The new combination *Typhlodromus mariposus* (Fox), therefore, is here used. Dr. Baker also has given us the following note concerning the genus *Typhlodromus:* "The mites in this group are free-living predators and have never been found to be true parasites as in *Laelaps*. . . . They are to be found on foliage of trees and plants, in debris, on animals, etc." We have five specimens of this mite from Tampa and Miami which have been determined definitely as *T. mariposus* (Fox), and three specimens which are probably this species but which cannot be determined specifically. Our records are as follows:

Typhlodromus sp., 1 female, collected by Marshall, January 28, 1947, Largo, Fla. *Rattus norvegicus* (Erxleben).

Typhlodromus sp., 1 female, collected by R. L. Scott, January 23, 1946, Tampa, Fla. *R. norvegicus.*

Typhlodromus sp., 1 female, collected by R. L. Scott, April 4, 1946, Tampa, Fla. *R. norvegicus.*

Typhlodromus mariposus (Fox), 1 female, collected by R. L. Scott, July 2, 1946, Tampa, Fla. *R. norvegicus.* (Examined by Dr. Fox.)

Typhlodromus mariposus (Fox), 4 females, collected by Hey, November 13, 1946, Miami, Fla. *R. norvegicus.*—8-18-47.

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Fox, Irving. 1946. A new genus, *Borinquolaelaps*, and new species of mites from rats in Puerto Rico. Jour. Parasit., **32**: 445–52.

[1] A contribution of the Typhus Control Program, CDC Activities, U. S. Public Health Service and the Florida State Board of Health.

[2] S. A. San. (R) U. S. Public Health Service.

[3] Medical Technologist, Division of Entomology, Florida State Board of Health.

Occurrence of the Brown Dog Tick in the Western States[1]

Glen M. Kohls and R. R. Parker, *United States Public Health Service*

The brown dog tick, *Rhipicephalus sanguineus* Latr., has become widespread in the United States since first reported by Banks in 1908 from Texas and New Mexico under the name of *R. texanus.* Bishopp & Trembly (1945) have mapped its distribution as indicated by collections of the Bureau of Entomology and Plant Quarantine. Their records indicate itoccurrence in practically all of the eastern and central states, and in Washington, California, Arizona, and Colorado among the western States. The purpose of this note is to report occurrence in four more of the western States: Montana, Wyoming, Utah, and Nevada. Specimens on which one of the Montana records was based were determined at the laboratory of the Montana Livestock Sanitary Board, Helena, all others were determined at the Rocky Mountain Laboratory of the United States Public Health Service, Hamilton, Montana.

Montana. Hardin, Big Horn County, February 23, 1947. Correspondent stated that the ticks were being found on the family dog and in the house on a wall adjacent to the furnace. According to a letter received October 26, 1947, ticks were still being found on the dog. A possible clue as to the source of this infestation was provided by the statement that the family had made a trip to Texas by auto in January 1946, and had taken the dog.

Helena, Lewis and Clark County, a record in June 1947 and another in September 1947. In the first instance the correspondent, who submitted specimens for determination, stated that the ticks were collected in a residence, in groups under the the wallpaper and elsewhere. In the second, numerous ticks were found on the dog by Dr. E. M. Joneschild of the Livestock Sanitary Board laboratory, who stated that the dog was a native of the Helena district.

Great Falls, Cascade County, October 1947. Specimens received were collected from a dog.

Wyoming. Casper, Natrona County, December 1938. Specimens received were collected in an apartment house.

Utah. Salt Lake City, May 15, 1943. Specimens received were collected from a dog.

Nevada. Boulder City, Clark County, October 22, 1946. Specimens received were collected in a residence and on a dog.

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Bishopp, F. C., and H. L. Trembley. 1945. Distribution and hosts of certain North American ticks. Jour. Parasitol. **31**: 1–54.

[1] From the Rocky Mountain Laboratory (Hamilton, Montana), National Institute of Health.

Toxicity of Some Synthetic Insecticides to Dogs

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There are many chemicals that give promise of controlling the more important ectoparasites of animals. Some of them have been tested and approved for use on animals; others are in the experimental stage and must be tested for their toxicity before being recommended for general use. This experiment was to determine the toxicity to dogs of three chemicals which have shown promise as insecticides.

The dogs were starved for 24 hours and then weighed. The desired dose was then calculated and weighed on an analytical balance. The toxicant was placed in number 13 gelatin capsules and sufficient cottonseed or Wesson oil was added to fill the capsule. The amount of the insecticide varied but the

Table 1.—Results of feeding benzene hexachloride, chlordan, and chlorinated camphene to dogs.

PREPARATION	WEIGHT OF DOG IN KGM.	DOSAGE OF ACTIVE INGREDIENTS MGM./KGM.	TOTAL AMOUNT GIVEN, MGM.	ESTIMATED TOTAL OF ACTIVE INGREDIENT, MGM.	SEX	RESULTS
Benzene Hexachloride, Wettable 6% gamma isomer	12.27	5	1188.69	71.35	Female	No effect
	15.9	10	2648.94	159	Male	No effect
	6.8	15	1699.32	102	Male	No effect
	13.18	20	4389.576	263.6	Male	No effect
	12.27	25	5110.455	306.75	Female	No effect
	15.9	50	13,244.7	795	Male	No effect
	13.18	60	13,164.72	790.8	Male	Slight diarrhea and vomiturition, back on feed
	6.8	75	8496.6	510	Male	Slight diarrhea and vomiturition, back on feed
Benzene Hexachloride, Technical 33–36% gamma isomer	21.68	100	6504.0	2168	Male	No effect
	21.36	200	12,816.0	4272	Male	No effect
	14.09	300	12,681.0	4227	Male	Slight diarrhea, pupil dilated, Nervous
	9.3	400	11,160.0	3720	Male	No effect
Toxaphene, 25% Chlorinated Camphene	7.95	20	636.0	159	Male	Convulsions and extreme salivation in 12 hr.
	8.4	30	1008.0	252	Male	Convulsions, tremors, diarrhea in 2 hr.
	6.36	40	1017.6	254.4	Female	Convulsions, tremors in 12 hours
	7.72	50	1544.0	386	Female	Convulsions, death in 3 hours
	9.54	60	2289.6	572.4	Male	Convulsions, death in 2 hours
	7.95	70	2226.0	556.5	Male	Convulsions, death in 3 hours
	6.36	80	2035.2	508.5	Female	Convulsions, death in 3 hours
Chlordane, Wettable 50% active ingredient	19.31	200	7724.0	3862	Male	Clonic spasms in 12 hours
	13.18	225	5931.1	2965.5	Female	No effect
	10.22	250	5110.0	2555	Female	Slowed respiration
	19.31	300	11,586.0	5793	Male	Clonic spasms, tremors in 4 hours
	13.18	400	10,544.0	5272	Female	Tremors, salivation, convulsions, blind
	10.22	500	10,220.0	5110	Female	Tremors, prostrate, convulsions
	4.54	700	6356.0	3178	Male	No effect

total volume was so adjusted that each dog received an equal amount. The capsules were placed in the mouth and the dog was made to swallow. Results are tabulated below.

SUMMARY.—In the series testing benzene hexachloride, the first product used contained 6% of the gamma isomer. Difficulty was encountered in the introduction of the massive doses required by the use of this low concentration. A product containing 33–36% of the gamma isomer was then used.

There was no toxic effect exhibited in dogs following the administration of benzene hexachloride at the rate of 50 mgm./Kgm. or less. The total amount given in the dose of 50 mgm./Kgm. was 13.24 grams. This would indicate that benzene hexachloride is safe to use on dogs in the concentrations and methods usually recommended.

The smallest dose of chlorinated camphene given was a total of .636 grams of 25% active ingredients or 20 mgm./Kgm. This did not produce death but did cause convulsions. Because of the high toxicity of toxaphene it is not recommended that this insecticide be used on dogs.

Indications are that Chlordane, like benzene hexachloride, is a relatively safe insecticide to use upon dogs. Dogs vary in their susceptibility to Chlordane. A dose of 200 mgm./Kgm. produced convulsions in one, while a 700 mgm./Kgm. had little effect.—11-22-47.

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Range of Northern Cattle Grub in Iowa

HAROLD GUNDERSON, *Ames, Iowa*

At a Livestock Pest Control Conference held in Cheyenne, Wyoming, in October, 1946, a question was raised as to the southern limits of the Northern cattle grub, *Hypoderma bovis* (DeG), in the United States. A number of years had passed since any surveys had been made of the range of the insect and Dr. F. C. Bishopp of the U. S. Bureau of Entomology and Plant Quarantine felt that it would be worth while to make more or less comprehensive surveys in the various western and northern states to determine the range of the insect.

In Iowa, both the northern cattle grub and the southern cattle grub, *Hypoderma lineatum* (DeV.), may be found in the same area and, in a few cases, in the same cattle. It was felt that a northern cattle grub survey should be conducted as late as possible in order to avoid the southern cattle grub, in northern Iowa particularly, as much as possible. For that reason, the survey was begun about May 10.

It has been established by surveys made in the early 1930's that the northern cattle grub was present in the 2 northern tiers of Iowa counties. These counties were therefore not asked to participate in the survey. The rest of the state was surveyed broadly by asking selected county extension directors over the state to contact operators of dairy herds to find out if grubs were present in the animals during May. If grubs were present, the county extension director was asked to go out to those farms and collect specimens, making sure that all the animals from which grubs were collected had been in Iowa for more than one year.

The response from our county extension directors

was excellent. They either mailed or brought preserved specimens, together with all the information, to Ames. All the specimens, in turn, were sent to Dr. E. W. Laake, of the U. S. Bureau of Entomology and Plant Quarantine at Kerrville, Texas. They were all determined as second and third instar larvae of *Hypoderma bovis* by R. W. Wells.

The survey indicates that the Northern cattle grub is present throughout the state. The intensity of infestation is not well known, but appears to be greatest in the northern two-thirds of Iowa.

This note is published in the hope that similar surveys will be conducted, in other states, where the range of *Hypoderma bovis* is not well known, with the assistance of county agricultural agents or vocational agriculture teachers who are familiar with their areas and who can assist entomologists in conducting such surveys.—10-2-47.

DDT to Control the Cattle Tick—Preliminary Tests

E. B. BLAKESLEE and W. G. BRUCE,[1] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The successful use of DDT for the control of many important ectoparasites on cattle has resulted in much speculation regarding the possible use of this insecticide for eradicating the cattle tick, *Boophilus annulatus* (Say). Because of the eradication campaign this tick occurs so rarely in the United States that there is little opportunity for experimental tests. The arsenical dip used for tick eradication is effective, but has some very objectionable features. Therefore, the tests reported in this paper were made to find out whether DDT would control the cattle tick. If this should be possible, many other ectoparasites of cattle that are practically unaffected by the arsenical dip could be controlled at the same time.

In May and June of 1946 permission was obtained from state and federal quarantine officials to conduct preliminary tests with DDT in a small area of south Florida where the tropical variety of this tick, *Boophilus annulatus microplus* (Can.), had recently reappeared. The infested area included most of the three counties north of Lake Okeechobee. The infestation was spotty rather than general, and was confined mostly to small areas in the affected zone.

The two principal measures now used in cattle tick eradication are (1) removing cattle, horses, and mules from heavily infested pastures for 8 or 9 months to "starve out" the larvae, and (2) dipping cattle at 14-day intervals in an arsenical dip containing 0.19 per cent of arsenious oxide. The tests with DDT were set up so that they would interfere as little as possible with this program.

PASTURE-SPRAYING TEST.—A 50-acre pasture from which all cattle had been removed recently and which was heavily infested with ticks was sprayed by airplane with a 20-per cent DDT emulsion. The emulsion was made from a concentrate containing 35 per cent of technical DDT, 60 per cent of commercial xylene, and 5 per cent of an aralkyl polyether alcohol.[2] The spray was applied at a calculated dosage of approximately 2 pounds of DDT per acre. The vegetation on the sprayed area varied from open grassland to dense palmetto hammock. The cattle tick larvae were readily picked up on a piece of white outing flannel dragged slowly over the ground. Results of the test were taken by dragging for uniform periods over previously established check locations, both before and after the spray was applied. Population reduction due to dragging was checked by parallel drags over adjoining unsprayed pasture.

The number of larvae collected before treatment was 711 at 15 locations in the area to be sprayed and 271 at 5 locations in the check areas. Within 24 hours after treatment only 34 larvae were recovered in the sprayed area, although the maximum mortality was not reached until 48 hours after spraying, when only 7 larvae were found. Many of the 34 surviving larvae recovered at 24 hours showed definite effects of DDT poisoning. No increase in mortality was indicated after 48 hours. In the unsprayed area the larval counts after 48 hours and after 7 days were 122 and 133, respectively. Heavy rains flooded the test area and prevented population sampling at the end of 1 month. Even with due allowance for population reduction due to dragging, the larva mortality was well above 90 per cent.

There was less difference in the results due to variation in ground cover than might be expected, although the largest recoveries of surviving larvae on sprayed pasture were obtained on open areas covered by a heavy growth of matted wire grass. It is difficult to estimate the practical usefulness of pasture treatments in an eradication program. Apparently the one spray resulted in good control but not eradication. The most significant result of this test was the definite indication that unengorged cattle tick larvae have a very low tolerance to light DDT residues.

CATTLE-SPRAYING TESTS.—A herd of 11 dairy cattle was released from compulsory dipping for tests with the DDT sprays. The herd was divided into 3 lots of 3 animals each and 1 lot of 2 animals. All the cattle had been dipped regularly every 14 days in the standard arsenical dip for some time prior to the tests. The pasture in which the herd grazed was moderately infested with tick larvae. The four lots of test animals were treated, respectively, with sprays containing 0.5, 0.75, 1, and 2.3 per cent of DDT. The sprays were made from a 50 per cent water-dispersible powder and were applied with an adjustable orchard gun operated from a small power sprayer with a pressure of about 300 pounds per square inch. Each animal was thoroughly saturated with about 1 gallon of the spray.

The most significant feature of this test was the apparent build-up in protection from repeated applications of DDT. The lots treated with the 0.5 and 1 per cent DDT concentrations were tick-free for 7 days after the first spray, but became reinfested at 14 days. After the third application of the 0.5 per cent concentration, and after the second application of the 1 per cent and 2.3 per cent concentrations, the cattle were tick-free for approximately 14 days. The lot containing only 2 animals had been left untreated for 1 week at the beginning of the test as a control. In deference to the eradication program, this lot was treated with the 0.75 per cent DDT spray on May 31. At that time both animals were infested with nymphs, larvae, and adults. Seven days after treatment both animals were still infested with nymphs and adults, but after another treatment on June 7 they remained tick-free for 14 days.

A marked improvement in the animals' skin condition was noticeable during the time they were

[1] The writers express their appreciation for the cooperation of the U. S. Bureau of Animal Industry and the Florida Live Stock Sanitary Board in making these tests possible.

[2] *Triton X-100.*

under test. When the animals were first examined on May 17, their skin was covered with light arsenical burns. When the tests were discontinued on June 21, this condition had completely cleared up.

Another series of tests was conducted at one of the vats where regular dipping operations were being carried on every 14 days. In these tests the same DDT concentrations that were used on dairy cattle were applied to small lots of infested beef cattle selected from a large herd. After treatment the cattle were released to graze with the remainder of the herd, which had been dipped in arsenical. The pasture was heavily infested with cattle ticks. After 14 days a comparison was made of the number of infestations found on the treated animals and on the animals dipped in arsenical. Because of considerable difficulty with the loss of identifying marks and inability to recover treated animals for inspection, less significant data were obtained from these tests than from the tests on dairy cattle. It was also impossible under this arrangement to determine the effect of repeated applications of DDT, since each lot treated was a fresh group of animals. In general the results were consistently similar to those obtained on dairy cattle. In one set of tests 17 animals treated with 1 per cent DDT spray and examined 14 days later had 9 animals tick-free, 5 infested with larvae, 3 with nymphs, and none with adults. In comparison with this, 16 animals dipped in arsenical had 7 tick-free, 5 infested with larvae only, 4 with nymphs, and none with adults.

DIPPING TESTS WITH DETACHED TICKS.—As a supplement to the other tests, detached female ticks engorged to various degrees of repletion were dipped in several concentrations of DDT. The ticks were dipped in the insecticide for 30 seconds and then placed in ventilated pill boxes for observation. The 0.19 per cent arsenious oxide dip was used as a control. The arsenical was probably somewhat more effective against engorged females than the DDT, although some egg deposition occurred regardless of the treatment. The eggs from females dipped in arsenical, however, failed to hatch, whereas in several instances those from females dipped in DDT sprays hatched in small numbers.

CONCLUSIONS.—Although the data obtained from the tests are preliminary, they offer considerable encouragement to the idea that DDT sprays might be used to eradicate the cattle tick. Some allowance must be made for the fact that the DDT was applied as a spray, which, in spite of every precaution, is not so thorough as dipping. In the spray tests in the pasture and on animals, DDT residues were consistently toxic to immature stages of the cattle tick, and especially to the larvae. How much use can be made of DDT in the eradication of ticks from pastures is uncertain, but it might be valuable for treating small isolated infestations or buffer areas. Even though the DDT was apparently less effective against adult ticks than was the arsenical dip, this does not preclude its use in a predetermined schedule of treatments.—10-25-47.

Effect of DDT on Dairy Cattle and Milk[1]

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Telford & Guthrie (1945) reported the transmission of the toxicity of DDT through the milk of goats fed oral doses of 1 gram of DDT per 8 to 9 pounds of body weight per day. Later Woodard *et al.* (1945) reported the appearance of appreciable amounts of DDT in the milk of dogs receiving oral doses of 80 milligrams of DDT per kilogram of body weight per day.

These dosages were relatively large considering the maximum amounts of DDT animals, such as dairy cattle, for instance, might ingest from eating heavily dusted forage or from licking themselves and herd mates after being sprayed for fly control. Forced feeding of smaller dosage of DDT to dairy cattle in production was undertaken in the spring of 1946 by the writers. Dosages fed were to approximate the amounts dairy cattle might ingest where DDT had been used to control insects on forage and to control flies on the cows.

PROCEDURE.—Two Holstein cows were secured from the Dairy Husbandry Department for the experiment. Technical grade DDT was given to the cows each day by means of capsule and balling gun. The animals were dosed each day, except Sundays, for a 29 day period.

Cow No. 73, weighing 1078 pounds at the beginning of the experiment, received twenty-five 20 gram doses of DDT during the period. This was a total of 500 grams of DDT, or an average daily dose of 43 milligrams per kilogram of body weight.

Cow No. 103, weighing 943 pounds at the beginning of the experiment, received twenty-one 5 gram doses of DDT during a 24 day period. This was a total of 105 grams of DDT, or 12.2 milligrams per kilogram of body weight per day. During the following 5-day period the daily dose for Cow No. 103 was increased to 40 grams per day for 4 days.

Both cows were milked once each day and were given the standard ration of dairy mash and alfalfa hay being fed to milking cows in the university herd. Samples from each day's milking were bioassayed for evidences of DDT, using houseflies as test animals. The veterinarian observed the cows each day for clinical symptoms of DDT poisoning or other abnormalities.

CLINICAL OBSERVATIONS:

Cow No.	Weight Gains: April 24 Wt. (lbs.)	Weight Gains: June 7 Wt. (lbs.)	Total Gain (Lbs.)
73	1078	1180	102
103	943	1035	92

No symptoms of acute DDT poisoning were evident in either cow during the experiment. Both cows became slightly nervous during the first week and showed stiffness in the hind quarters during that time. Milk production of both animals was reduced by half at the end of the experiment. This loss in milk may have been occasioned by the change from two milkings per day to one milking per day during the experiment. This, too, may have influenced the gains in weight recorded.

RESULTS OF BIOASSAY.—Milk from Cow No. 73 showed a high degree of toxicity to houseflies 24 hours after the initial 20 gram dose of DDT was administered. High toxicity persisted for 9 days or until 140 grams had been ingested by the cow. Thereafter, the toxicity of the milk to the flies was quite variable from day to day indicating that excretion of

[1] Missouri College of Agriculture Journal Series No. 1076.
[2] Departments of Entomology and Veterinary Science, respectively.

the DDT through the milk fluctuated markedly. Ten days after the last 20 gram dose was administered to the cow the milk ceased to be significantly toxic to the test flies.

Milk from Cow No. 103, receiving the 12.2 milligrams per kilogram of body weight per day, failed to show high toxicity to test flies except on the eighth day. Preceding that day and thereafter no significant toxicity was recorded among the tests. Later when the DDT dosage was increased from 5 grams per day to 40 grams per day (12.2 milligrams per kilogram of body weight per day to 97 milligrams per kilogram of body weight per day) the milk became highly toxic to the test flies within 24 hours and remained so for 3 days. Fifteen days after the last 40 gram dose was administered to Cow No. 103 the milk ceased to be toxic to the test flies.

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Benzene Hexachloride in Cream from Cows' Milk[1,2]

DEANE P. FURMAN and W. M. HOSKINS

Benzene hexachloride does not lend itsef readily to chemical analysis, and the expense involved in spectrophotometric methods of analysis places such techniques beyond the reach of most investigators. However, the increasing use of this material as an insecticide, on animals as well as on plants, has made it imperative that assays be made to determine any potential hazards involved, at least through absorption or excretion in treated animals.

As pointed out by Furman (1947), the results of laboratory tests on mice indicate that there is some absorption of benzene hexachloride through the skin following application in an aqueous suspension.

The purpose of this work was to determine the presence or absence of benzene hexachloride in the milk of cows following spraying with aqueous suspensions of benzene hexachloride.

TECHNIQUE.—A commercial mixture was used composed of 50 per cent technical benzene hexachloride, 0.75 per cent sodium lauryl sulfate, and the remainder a mixture of inert diluents. According to the manufacturer, the alpha isomer of the benzene hexachloride was 65 to 75 per cent, beta 6 to 8 per cent, gamma approximately 12 per cent, and delta 6 to 7 per cent. Forty-five grams of the commercial benzene hexachloride mixture was administered orally in capsules to cow number 332. Cows number 437 and 453 were each thoroughly drenched with an aqueous spray composed of 0.5 per cent technical benzene hexachloride in suspension. Animal number 437 was unrestrained following treatment, while number 453 was prevented from licking its body for the duration of the experiment. Cow number 303 was untreated. All animals were from the University of California herd at Berkeley.

Milk samples were taken from the cows by means of sterile milk tubes, following thorough cleansing of the udders. Since the cows were nursing calves, it was necessary to separate them from the calves at least 4 hours before collecting samples.

The reference mortality curve for known amounts of toxicant was obtained in two ways. In method "a," acetone solutions containing known amounts of the γ-isomer in technical benzene hexachloride were placed in shell vials, evaporated and the vials then kept at 70° C. for 5 minutes to remove all solvent. Twenty-five to 30 houseflies, reared by the Peet-Grady method and 4 to 5 days old, were then introduced and left for 30 minutes, after which they were transferred to observation cages. Mortality was determined after 24 hours. In method "b," which is a modification of the procedure described by Schechter *et al.* (1946) for samples containing DDT, one ml. of cream known to be free of benzene hexachloride was added to known amounts of γ-isomer in chloroform and the mixture treated with concentrated sulfuric acid-sodium sulfate, with 1:1 fuming sulfuric acid-concentrated sulfuric acid and then again with the sulfuric acid-sodium sulfate. The chloroform layer was shaken twice with sodium bicarbonate solution and then evaporated in a shell vial as before. The rest of the procedure was as described above. In the case of milk from the treated cows, 1-ml. samples of cream were treated by method "b."

From the data given in table 1, it is seen that benzene hexachloride was recovered from the milk of sprayed cows as well as from the animal receiving an oral dose. That this indicates a definite absorption through the skin is proven by the fact that animal number 453 was prevented from licking its body following spraying. R. H. Hackman (1947) has brought forth evidence that the most important factor causing removal of DDT from cattle sprayed with DDT preparations is licking, either by the animal concerned, or by another animal.

Animal number 437, treated with 0.5 per cent benzene hexachloride spray produced the greatest yield of the material of 5.5 parts per million of gamma isomer equivalent in the cream. The presence of benzene hexachloride in this sample as well as in that from animal number 332 on the same day was readily detected by the musty odor of the cream. Individuals ignorant of the origin of the milk were able to distinguish the contaminated from uncontaminated samples.

No appreciable quantity of benzene hexachloride was detected in the cream by the fly test after one week following treatment.

In analyzing these results it should be recognized that the yields of gamma isomer from the cream samples, while significant, indicate only minimum amounts of the benzene hexachloride present, for there is no proof that the extraction method used recovered all of the benzene hexachloride from the milk. That the technique probably removed most of the material is indicated by the fact that no further kill of flies was obtained by testing additional extractions from the sulfuric acid solution used in the original extractions.

It will be observed in table 1, columns 4 and 5, that the two methods of determining the standard mortality curve led to approximately the same results for the experimental samples of milk. However, it was discovered after this work was completed that there is a loss of toxic substance when residues of an acetone or chloroform solution of pure isomer are heated at 70° C. for 5 minutes. It is probable that a smaller loss occurred when the residues from technical benzene hexachloride or from pure γ-isomer

[1] Contribution from the Division of Entomology and Parasitology, University of California, Berkeley.

[2] The skillful assistance of Mr. P. S. Messenger and Mr. O. H. Fullmer in carrying out the bioassays is gratefully acknowledged.

Table 1.—Amounts of γ-isomer equivalent in cream from milk produced by cows treated with benzene hexachloride as described in column 1.

METHOD OF APPLICATION	DAYS AFTER TREATMENT	FLY MORTALITY PER CENT	ppmγ-isomer EQUIVALENT a[1]	ppmγ-isomer EQUIVALENT b[2]	ODOR FROM VIALS
(No. 332) 45 grams 50% technical benzene hexachloride per os (40 mg benzene hexachloride/kg body weight)	1	59	2.4	4.2	strong
	5	10	0.6	2.0	none
	11	0	0	0	none
(No. 437) drenched with 0.5% benzene hexachloride suspension (licking not prevented)	1	85	4.4	5.5	strong
	2	63	2.5	4.2	mild
	3	18	1.1	3.0	mild
	5	7	0.4	1.5	mild
	6	14	0.7	2.7	slight
	8	4	0.2	1±	very slight
	10	0	0	0	none
	11	0	0	0	none
(No. 453) ditto (licking prevented)	2	24	1.4	3.2	
	3	37	1.8	3.7	
	4	3	0.1±	1±	
	5	0	0	0	
	7	4	0.2±	1±	
	8	0	0	0	
	9	4	0.2±	1±	
(No. 303) untreated		0, 0 (two trials 5 days apart)			

[1] Based on mortality curve obtained with technical benzene hexachloride dissolved in acetone.
[2] Based on mortality curve obtained with γ-isomer plus milk fats dissolved in acetone.

plus cream were heated in this manner. Since the experimental samples were also treated by method "b" the losses should have been comparable and on this basis the results in column 5 may be taken as more reliable than those of column 4. Consideration of this problem led to the decision to avoid evaporation at an elevated temperature in future work. An improved procedure including this and other changes will be discussed fully in a later report. The last column of table 1 expresses the relative intensities of odor of benzene hexachloride observed with each vial as it was taken from the oven. A general agreement with the mortalities of the houseflies is obvious, and it may be noted that the human nose is a delicate detector of this compound when other strong odors are absent.

The amount of benzene hexachloride present in the milk of the treated cows was probably too low to present an actual health hazard to consumers of the milk. This was indicated further by the fact that there was no apparent injury to nursing calves. However, there is a possibility that milk products taken from cows within 4 to 7 days following treatment with 0.5 per cent benzene hexachloride would have a musty odor rendering them unpalatable.

A further factor of significance to consider is contained in a statement of the Federal Food, Drug and Cosmetic Act which holds that a food is adulterated if it contains any added poisonous or deleterious substance not *required* in the production of the food.

A consideration of the above mentioned factors leads to the conclusion that it is inadvisable to spray or dip lactating dairy cattle in aqueous suspensions of benzene hexachloride unless the milk obtained for a week following treatment is used for other than human consumption.

SUMMARY.—A biological assay method was developed for the detection of benzene hexachloride in terms of gamma isomer equivalent in milk.

Lactating cows were treated with a drenching spray of 0.5 per cent benzene hexachloride in aqueous suspension or fed 40 mg technical benzene hexachloride per kg. body weight. The base mixture was a 50 per cent benzene hexachloride dust containing approximately 6 per cent gamma isomer.

A maximum recovery of 5.5 parts of gamma isomer per million was obtained from cream on the day following treatment. Smaller amounts were recovered in the cream for as long as 9 days following treatment in one instance.

A definite odor was noted in cream later found to contain four or more p.p.m. of γ-isomer equivalent (approximately 30 parts technical benzene hexachloride per million).

Since milk containing a detectable quantity of benzene hexachloride is classifiable as an adulterated food under the Federal Food, Drug and Cosmetic Act, and since very small quantities in the cream produce a musty odor, it is deemed inadvisable to spray or dip dairy cattle with aqueous suspensions of benzene hexachloride unless the milk obtained for at least 1 week following treatment is used for other than human consumption.—11-14-47.

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Aristotelia fragariae on Strawberries in Iowa

D. ELMO HARDY

The strawberry crown miner, *Aristotelia fragariae* Busck, appears to be well established throughout the northern half of Iowa. Infestations were found in six localities, last season, ranging from the west border to within two counties of the east boundary. This species is a common pest of strawberries in the Pacific Northwest but apparently has not been reported before east of the Rocky Mountains.

In several Iowa localities severe damage was caused by this insect. Many plantings were observed which had been completely destroyed by the miners.

The miners overwinter in the strawberry crowns as mature larvae. Pupation takes place early in the spring and the adults emerge about the middle of June. Egg laying begins the later part of June and continues through early July. The egg period lasts about ten days and the peak of egg hatching occurs about the 15th of July. The young larvae wander over the leaf surface for a short time before dropping to the base of the plant. They bore into the crown near the upper portion, just below the bases of the leaves. The larval stadia extend approximately 2 weeks each. They reach maturity in September and winter in silken cases near the base of the crown. The larvae are readily distinguished from all other crown borers by the carmine pink color, elongate form and small size (length 7.0 mm.).

Preliminary chemical control experiments were conducted this season using DDT and very excellent results were obtained. The data obtained indicate that this insect can be controlled with one or two carefully timed applications of 5 to 10 per cent DDT dust. One application put on at the peak of the egg hatching (July 15) apparently gave complete control. The untreated plots were totally destroyed by the miners.—3-1-47.

Seed Yields of Red and Ladino Clovers Increased by Use of Insecticides[1]

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Experiments made in Wisconsin in 1945 and 1946 by Medler and Scholl (1947)[2] showed that increased yields of alfalfa seed were obtained by the use of insecticides. Since it is desirable also to know the effect of insecticides on other legume seed crops, experiments were conducted by the writers on red and ladino seed clover fields during the 1947 season.

A ten-acre ladino clover field near Ashton, Dane County, was divided into 28 plots, 16 of which were used for dust treatments in four replicates, and 12 used for spray treatments in three replicates, including untreated checks. Dusts were applied with a self-propelled machine at the rate of approximately 40 pounds per acre. The sprays were applied at approximately 100 gallons per acre with low-pressure type equipment that had been used previously for weed-control spraying. The insecticides were applied on July 3, when the clover was partially in bloom. Maximum production of flower heads took place about ten days afterward.

A strip 34 inches wide and 100 feet long was cut in each plot on September 3 in order to estimate seed yields. The samples were threshed by a combine, and the seed re-cleaned before weighing. Although an effort was made to adjust the combine for maximum efficiency, a re-threshing of bulk material left after the first threshing yielded half again as much seed. While the yields given in Table 1 probably represent only two-thirds of the actual seed produced, those from dusted plots averaged slightly higher than those from sprayed plots, and all of the treated plots had higher average yields than the untreated checks.

Table 1.—Pounds of ladino seed per acre obtained from samples in plots treated with insecticides on a farm near Ashton, Wisconsin, in 1947.

TREATMENT	AVERAGE YIELD	INCREASE OVER CHECK, PER CENT
Dusts		
5% DDT in pyrophyllite	188	34
2.5% DDT in pyrophyllite	180	29
2.5% DDT+5% sabadilla 50–50 mixture in pyrophyllite	181	29
Untreated check	140	
Sprays		
DDT—1 lb. per acre	183	22
DDT+sabadilla 0.5 lb. per acre of each	161	7
Chlordan—1 lb. per acre	171	14
Untreated check	150	

Table 2.—Pounds of red clover seed per acre obtained from samples in plots treated with insecticidal sprays on a farm near Cambridge, Wisconsin, 1947.

TREATMENT	AVERAGE YIELD	INCREASE OVER CHECK, PER CENT
DDT—1 lb. per acre	67	76
Benzene hexachloride (5% gamma)—1 lb. per acre	49	29
DDT+sabadilla—½ lb. of each per acre	62	63
DDT+benzene hexachloride (5% gamma)—0.5 lb. of each per acre	48	26
Untreated check	38	

[1] Supported in part by the Research Committee of the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation.

[2] Medler, J. T., and Scholl, J. M. 1947. Control of Insects Affecting Alfalfa Seed Production in Wisconsin. JOUR. ECON. ENT. 40: 579–581.

A fifteen-acre red-clover field in Jefferson County near Cambridge was used. Insecticides were applied with a low-pressure type weed sprayer at the rate of 100 gallons per acre. Plots were one acre and treatments were replicated three times. The sprays were applied on July 25 in the pre-bloom stage of plant growth.

The seed yields were estimated from strips 5 feet wide and averaging 333 feet long, cut out of each plot on September 5 and threshed with a combine. The seed was re-cleaned before weighing. As shown in Table 2, the average yields of treated plots were greater than the average yields of the untreated check.

The season of 1947 was not favorable for heavy insect infestations in legumes. Sweepings made when the insecticides were applied showed only light infestations of *Lygus oblineatus* (Say) and *Adelphocoris lineolatus* (Goeze) in both the ladino and the red clover and of lesser clover leaf weevil (clover bud weevil), *Hypera nigrirostris* (F.), larvae in the red clover. Circumstances made it impossible to record insect populations in the plots after treatment.

Owing to the extreme variation among blocks, no materially significant differences among the treatments could be shown by statistical analysis. Nevertheless, the data indicate that all of the insecticides tested increased the yield of ladino and red clover seed. DDT consistently gave the best yields whether applied as a 5 per cent dust or as a spray at one pound of actual insecticide per acre. The superiority of DDT was also evidenced during the same season in experiments on alfalfa.

Effect of Citrus Red Mites on a California Red Scale Population

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In a study of the effect of the host plant on the biology of the California red scale, it was found that the usual differences caused by the host species could easily be nullified or intensified by an accidental infestation of mites on one or the other of the hosts. Likewise it was necessary that the host plants should not be infested with mites before being used in the experimental work. This was clearly demonstrated in an experiment in which a number of orange and lemon seedlings had been infested with the newly emerged young, commonly known as "crawlers," of the California red scale, *Aonidiella aurantii* (Mask.), and were subsequently accidentally infested with the citrus red mite, *Paratetranychus citri* McG. While over half of the red scale crawlers were able to settle and continue development when the leaves were first infested, the next generation of crawlers were unable to settle on the leaves except in very limited numbers. On the other citrus seedlings, free of mites, the settling and development of the scales continued in a normal manner. This indicated that the mites, while able to continue their development on the plants, had nevertheless rendered them unsuitable for the red scale.

An experiment was made in a laboratory at room temperature, in which 30 adult mites were placed on each of two leaves of an orange seedling, and the petioles of the leaves were smeared with a sticky banding material to keep the mites on the leaves. One hundred red scale crawlers were placed on each leaf at various intervals of time, indicated in figure 1, for a period of two weeks. If and when they reached a stage in their development known as the "whitecap" stage, which requires less than two days, they were counted and removed. Altogether 1300 crawlers were placed on the two leaves. The percentage that were able to settle and form whitecaps, at first about 50 per cent, declined each day until on the twelfth day no whitecaps were found, meaning that the crawlers had died without being able to complete even the first instar of their development. The decline in the number of crawlers able to survive on the leaves is graphically represented in figure 1.—12-20-47.

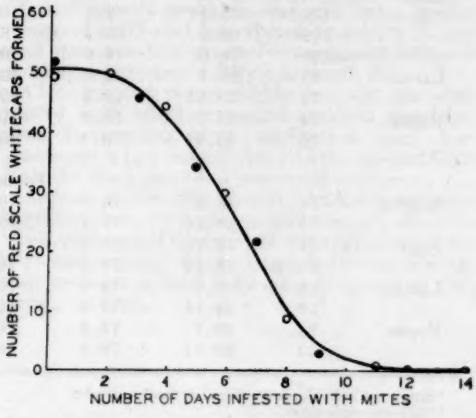

FIG. 1.—Effect of a citrus red mite infestation on the per cent of California red scale settling and forming whitecaps on orange leaves. Open and closed circles in graph represent the separate data points for the two leaves used in the experiment.

The Effect of Prolonged Exposure to High Vacuum on Stored-Tobacco Insects

C. O. BARE,[1] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

During the course of experiments with new fumigants against the tobacco moth, *Ephestia elutella* (Hbn.), and the cigarette beetle, *Lasioderma serricorne* (F.), it seemed desirable to determine the effect on these insects of prolonged exposure to high vacuum alone. The effect of vacuum on several species of insects and a review of the literature on the subject have been published by Back & Cotton (1925). Little information is available on the effect of vacuum on the tobacco moth or the cigarette beetle, although Runner (1919) reported negative results in exposing adults and eggs of the cigarette beetle, then known commonly as the tobacco beetle, to a vacuum of about 28.5 inches for periods of 1 to 24 hours.

At Richmond, Va., in 1946 and 1947, tests were conducted in a 33-cubic-foot steel vacuum chamber equipped with a mercury manometer, a thermometer, and a pressure gauge. Test spikes containing all stages of both the tobacco moth and the cigarette beetle were driven into bales of Turkish tobacco, which were then placed in the chamber. The number of insects of each stage placed in a section of test

[1] Thanks are due Ross W. Brubaker for cooperation in recording results.

Table 1.—Mortality of stages of the cigarette beetle and the tobacco moth when exposed to vacuum at Richmond, Va., 1946–47. (Average of five replications of each treatment, except as noted.)

Stage of Insect	Exposure Period (Hours)	Average Vacuum in Inches of Mercury	Average Temperature of Chamber °F.	Per Cent Mortality in Tobacco at Depths of—					
				1 inch	3 inches	5 inches	7 inches	9 inches	Check
Cigarette Beetle									
Adults	24	28.7	76.2	99.2[1]	100	100	99.2[1]	100	11.2
	72	28.11	79.1	100	99.2[1]	98.4[1]	100	96.8[1]	4
Eggs	24	28.7	76.2	0	0	0	0	0	0
	72	28.11	79.1	10	4	10	10	18	0
	168[2]	28.5	68.5	99.75[3]	—	—	—	—	0
	240[2]	28.6	74.0	100[3]	—	—	—	—	0
Larvae	24	28.7	76.2	100	100	100	99.2	100	0.8
	72	28.11	79.1	100	100	100	100	99.2[1]	8
Pupae	24	28.7	76.2	96	96	86	90	92	0
	72	28.11	79.1	100	100	100	100	98[1]	0
Tobacco Moth									
Adults	24	28.7	76.2	100	100	100	100	100	0
	72	28.11	79.1	100	100	100	100	100	0
Eggs	24	28.7	76.2	0	0	0	0	0	0
	72	28.11	79.1	100	100	100	100	100	0
Larvae	24	28.7	76.2	100	100	100	100	100	0
	72	28.11	79.1	100	100	100	100	100	0
Pupae	24	28.7	76.2	100	100	95[1]	100	100	0
	72	28.11	79.1	100	100	100	100	100	0

[1] Surviving individuals moribund or badly crippled.
[2] Only one replication.
[3] Eggs not placed in the tobacco. (One egg hatched out of an estimated 250 in the 168-hour exposure.)

spike varied because of space and other considerations. For the cigarette beetle the numbers were as follows: 25 adults, 25 nearly mature larvae, 10 pupae, and 10 eggs; for the tobacco moth, 1 adult (since a greater number tend to kill each other in close confinement), 4 nearly grown larvae, 4 pupae, and 50 eggs. Similar numbers were retained as checks. Test insects were placed in the tobacco in a random arrangement at depths of 1, 3, 5, 7, and 9 inches. The pump was operated for about 35 minutes to produce a vacuum above 29 inches. For exposure periods longer than 72 hours it was necessary to repump the vacuum approximately every third day to above 29 inches in order to keep it from leaking down to 27 inches. Five replicates of the tests were conducted for a 24-hour exposure and five replicates for a 72-hour exposure; and since the cigarette beetle eggs proved to be most resistant, one test of eggs was run for 168 hours and another for 240 hours. The ranges of vacuum during the exposures were: For 24 hours, 29.3 to 28.1 inches; for 72 hours, 29.4 to 26.1 inches; for 168 hours, 29.4 to 27.5 inches; and for 240 hours, 29.3 to 27.3 inches. The results of the tests are summarized in table 1.

In the 24-hour exposures the mortality of cigarette beetle adults and larvae and of tobacco moth adults, larvae, and pupae, was nearly 100 per cent. The cigarette beetle eggs appeared to be unaffected, except that they were slower in hatching, and only 86 to 96 per cent of the cigarette beetle pupae were killed. Approximately 100 per cent of all stages of the tobacco moth were killed, except the eggs, which were slower in hatching but otherwise appeared to be unaffected.

In the 72-hour exposures practically 100 per cent mortality was obtained of all stages of the cigarette beetle, except the eggs, most of which hatched. All stages of the tobacco moth, including the eggs, were killed.

Since 96 to 82 per cent of the cigarette beetle eggs hatched after the 72-hour exposures, one replicate of a 168-hour (7-day) test was conducted. In this, a single egg hatched. Then a 240-hour (10-day) test was tried and it resulted in complete mortality of all the cigarette beetle eggs exposed, an estimated 750.

No differences in per cent mortality due to the 1- to 9-inch depths in the tobacco could be detected.

Since the length of time required for vacuum alone to produce mortality is much greater than the usual 3- to 4-hour exposure with fumigants, it is evident that in fumigation at reduced pressure the effect of vacuum in producing mortality of the insects is almost negligible, and the kills are due principally to the fumigants used.

The mortality obtained in these tests appears to be due largely to desiccation, and the cigarette beetle eggs have a waxy covering, which is very resistant to drying.

The results of the tests indicate that if it were practical to keep manufactured tobacco products in vacuum for a period of approximately 10 days, complete mortality of all stages of the cigarette beetle and the tobacco moth would be obtained.—9-25-47.

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Control of Grasshoppers in Apple and Peach Orchards

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During the summer of 1947, a heavy infestation of two species of grasshoppers *Melanoplus femur-rubrum* DeGeer and *M. differentialis* Thomas were reported from several counties in Western Maryland. The principal report of damage came from orchardists, but damage occurred to several other farm crops. On July 26, a series of plots was laid out in an apple orchard where a heavy population of grasshoppers was present. Both spray and dust formulations were used in this orchard, and were applied with the regular portable orchard equipment.

On August 20, a serious infestation of grasshoppers was reported in a peach orchard in another section of the county. Upon investigation, it was found that several hundred bushels of peaches had been ruined as the result of the feeding. In an adjoining apple orchard, the grasshoppers were causing serious defoliation of the apple trees. The peach orchard was dusted on August 21, using benzene hexachloride formulation, which was applied with a portable duster. The apple orchard was dusted on August 21 from an airplane, and 3 days later with a portable duster.

On September 4, further large scale tests were conducted in an apple orchard which had a heavy cover crop of clover. The infestation in this orchard was very heavy, but the grasshoppers confined their feeding to the clover and the leaves on a few lower limbs.

The spray and dust formulations, the date of treatment, the number of gallons of spray and pounds of dust per acre, the amount of toxicant per per acre, and the approximate control with the different materials are shown in the table below.

Benzene hexachloride 6 per cent gamma isomer at a minimum of 4 ounces of toxicant per acre was effective against young grasshoppers, but a similar dosage of a different formulation containing 25 per cent gamma isomer was ineffective against matured grasshoppers approximately one month later.

Chlordan at 2 pounds of the toxicant per acre proved quite effective against matured grasshoppers. Two weeks after application very few grasshoppers had crossed over into the sprayed field from the check plots and unsprayed borders.

Airplane application of dust containing benzene hexachloride in an apple orchard was not effective when .48 pound of the toxicant was applied per acre. This was probably due to tree interference causing poor coverage around the base and spread of the limbs.—11-7-47.

	Formulations	Date of Treatment	Toxicant Mixture Per 100 Gallons	Application Per Acre	Toxicant Per Acre	Per Cent Kill
1						
	Toxaphene, 50% wettable powder	July 26	5 lbs.	200 gals.	5 lbs.	90
	Toxaphene, 50% wettable powder	July 26	3 lbs.	200 gals.	3 lbs.	60
	Benzene hexachloride 6% gamma isomer	July 26	2 lbs.	200 gals.	.24 lb.	99
	Benzene hexachloride 25% gamma isomer	July 26	1 lb.	200 gals.	.50 lb.	100
	Hexaethyl tetraphosphate 50% formulation	July 26	1 pt.	200 gals.	1 pt.	50
	Tetraethyl pyrophosphate	July 26	4 ozs.	200 gals.	8 ozs.	90
	DN-111	July 26	2 lbs.	200 gals.	.8 lb.	0
	50% wettable sulfur, 30% talc, 20% Benzene hexachloride containing 6% gamma isomer	Aug. 21		100 lbs. applied by portable duster	1.2 lbs.	100
	80% talc, 20% Benzene hexachloride containing 6% gamma isomer	Aug. 21		40 lbs. applied by airplane	.48 lb.	50
	80% talc, 20% Benzene hexachloride containing 6% gammaisomer	Aug. 21		100 lbs. applied by portable duster	1.2 lbs.	100
2	Chlordan 50% wettable powder	Sept. 4	2 lbs.	200 gals.	2 lbs.	99.5
3	Chlordan 40% emulsifiable	Sept. 4	1 qt.	200 gals.	.8 qt.	99.5
3	Chlordan 50% wettable powder	Sept. 4	2 lbs.	200 gals.	2 lbs.	99.5
4	Benzene hexachloride 25% gamma isomer	Sept. 4	8 ozs.	200 gals.	.25 lb.	75.0

Preliminary Results of Termite Soil-Poisoning Tests

R. J. KOWAL and R. A. ST. GEORGE, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In the study of subterranean termite control methods it is generally recognized that structural measures are of prime importance; that these measures, if properly applied, offer permanent protection; and that soil poisons, although beneficial, are less permanent and should be used only where structural methods are impractical or as an adjunct to them. Studies on the practical application of soil poisons in buildings in Asheville, N. C., during the period from 1938 to 1940 revealed that approximately 75 per cent of termite infestations were due to faulty construction and could be largely remedied by structural methods of control. Such infestations were found principally at filled porches, terraces, and other entrance structures. A similar situation was found in the District of Columbia where, in addition to entrance infestations, many basement apartments were damaged. Control of such infestations is often difficult and complex, but consists in the main of blocking off the entry of the termites with concrete or other impervious material, though in many places soil poisons must be applied as a supplementary measure.

Other measures recommended for discouraging termite activity include adequate drainage around buildings, ample ventilation under buildings, and removal of wood debris, which provides breeding material. While these requirements apply generally to all construction, they have particular application throughout the South, especially in the states where basementless dwellings are common and conditions are exceptionally favorable for termite activity.

In such basementless dwellings soil poisons have their widest application. Poisoning of the soil specifically for termite control has been practiced for approximately 20 years, and numerous chemicals and chemical mixtures have been used with varying success. As use of the method became more widespread, numerous agencies and individuals displayed interest in development of tests that would evaluate chemicals for such use. Much good information was accumulated during these early years, but a lack of uniformity left considerable doubt as to the relative value of the different chemicals being used. In 1939 a conference was held by representatives of several public and private agencies, to draw up a standard procedure for testing and evaluating chemicals used as soil poisons for termites. The following are some of the most important points set forth in the outline formulated at this meeting:

(1) In the selection of an experimental area, uniformity of site, soil type, and vegetative cover was stressed. Determination of the general distribution of termites over the experimental area was specified.

(2) A randomized-block design was decided on, with the area divided into 10 uniform blocks representing the number of replications to be made of each chemical treatment.

(3) Chemical treatment was to consist of digging a hole 15 inches in diameter and 19 inches deep (removing about 2 cubic feet of soil), and treating the soil as it was replaced. A wooden stake 2 by 4 by 18 inches was to be driven in the center of this plot to a depth of 12 inches. The species of wood and its density were specified.

(4) Treatment stakes and control stakes were to be arranged at random and set on vertices of 5-foot equilateral triangles.

(5) At least three rates of application were specified for each chemical, 8 ounces of toxic material per cubic foot having been selected as a standard. Other dosages could be selected by the investigator, special consideration being given to the relative cost of the chemical.

One untreated control stake was specified for each of the 10 blocks, though a larger number was considered desirable.

A number of these standardized experiments are in progress, and it is hoped that data from all of them may soon be brought together for analysis. In 1942 and 1943 one such experiment was established at the Agricultural Research Center at Beltsville, Md., and another on Barro Colorado Island, in the Canal Zone. More recently additional experiments were set up at Saucier, Miss., and in the Canal Zone.

A total of 74 different treatments, with 27 chemicals and chemical mixtures, were tested at Beltsville. These treatments included chemicals and dosages generally recommended for termite control and a few that had not been tried before. Certain chemicals were tested to determine whether they might be used as substitutes for others of which a critical shortage developed during the war. Some that appeared promising in the laboratory were tested to determine whether they would hold up under service conditions. The data obtained thus far are too extensive to report in detail at this time.

A few of the most interesting results might be mentioned. Lead arsenate, used dry at rates of 4, 8 and 16 ounces per cubic foot, has held up surprisingly well after 4 years of service. After 3 years of exposure sodium arsenite used dry, and also in 10 per cent solution at low dosages has held up remarkably well. Sodium fluosilicate, cryolite, and phenothiazine used dry also show promise. Diphenylamine and pthalonitrile, which appeared excellent in laboratory tests, have failed. Trichlorobenzene alone and in combination with 5 per cent of pentachlorophenol has shown up very well. This strength of pentachlorophenol when used alone shows weakness in low dosages, and the high dosage, which is equivalent to 10 quarts per 10 cubic feet, may be the minimum strength from which effective protection can be expected. Results of tests with orthodichlorobenzene appear very erratic, even in a dosage equivalent to 1 gallon per 10 cubic feet. It appears that DDT may be of some value as a soil poison, since no attacks have occurred in treatments in which a 5 per cent solution in fuel oil was used. The value of this treatment was doubtful for some time, because oil treatments alone were unattacked for 2 years.

Because of various limitations during the war period, the tests established in the Canal Zone 3 years ago were not so extensive as those at Beltsville. Termite activity in that area is so severe that much higher dosages were used than at Beltsville. An examination at the end of the 3-year period revealed very clear-cut results. All mixtures of creosote with diesel oil, and orthodichlorobenzene with diesel oil, in dosages up to and including 3.5 gallons per 5 cubic feet, failed completely. Five per cent of pentachlorophenol in diesel oil showed one failure in a dosage of 3.5 gallons per 5 cubic feet. There were no failures with orthodichlorobenzene alone at this dosage. Sodium arsenite held up 100 per cent in all dosages used, the lowest being equivalent to 3.0 gallons of 10 per cent solution per 5 cubic feet. Un-

doubtedly these dosages are extremely high and, in practical application, the cost of treatment might appear excessive, but it is readily apparent that the severity of exposure in Panama requires this heavy treatment. The condition of the check stakes well demonstrates this severity; of 30 check stakes used all were attacked and most of them completely destroyed. It appears quite likely that at the end of a 5-year period all Canal Zone treatments will have failed completely, with the possible exception of the highest dosages of sodium arsenite.

Numerous tests have been conducted in the practical application of soil poisons to control termites in buildings. The poisons have been applied mostly by common labor, which many times could not be closely supervised. Failures have occurred among some of the soil poisons that had previously proved their value under experimental conditions. This experience brings out a point of utmost importance in soil-poisoning operations—namely, that regardless of the potential value of the soil poison being used, treatment of the soil must be complete if termites are to be successfully isolated from wooden structures.

Powder-post Beetles in Imported Bamboo

W. W. JUDD[1]

On November 24, 1947 an investigation was made of the occurrence of beetles in a shipment of bamboo in the stock of a company manufacturing decorations and window displays in Hamilton. The bamboo had been imported from Florida and consisted of about 40 stalks about 10 feet long and 1 to 4 inches in diameter. Numerous emergence holes, about .06 inch in diameter, appeared over the surface of the stalks. Many small beetles, *Dinoderus minutus* Fabr.,[2] were crawling about on the stalks and in a pile of fine wood powder at the base of the stalks. Slight pressure on the sides of the stalks caused the walls to collapse, disclosing the wood riddled with galleries, and a fine powder of wood filling the cavities in the internodes of the bamboo. Beetles were crawling actively in the galleries of the wood. No larvae were found when the stalks were broken up and the wood was examined.—12-8-47.

[1] Lecturer in Zoology, McMaster University, Hamilton, Ontario.

[2] Determined by Mr. W. J. Brown, Division of Systematic Entomology, Department of Agriculture, Ottawa.

Application of Milky-Disease Spore Dust with a Commercial Fertilizer

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The effectiveness of *Bacillus popilliae* Dutky in controlling larvae of the Japanese beetle, *Popillia japonica* Newm., has been repeatedly demonstrated under field conditions. It has been found that applications of a dust containing spores of this organism to soil infested with Japanese beetle larvae causes them to become infected with type-A milky disease.

The usual method of preparing this dust is to impregnate a carrier, such as a mixture of chalk and talc, with known numbers of spores of the pathogen. Spore-laden dust prepared in this way can be held indefinitely and can be standardized so that a definite dosage can be applied to any given area.

Generally spore dust has been applied in spots spaced at regular intervals rather than uniformly over any area. A number of machines are available which can be used to apply dust on the surface of the ground, but it is difficult to apply a small amount of this material evenly with most of them. This difficulty can be overcome in part by diluting the stock spore-dust material.

The question arose as to whether the milky-disease spore dust could be mixed with a fertilizer and the two materials applied simultaneously. In 1940, to obtain information on such a means of application and to test the effect of a standard fertilizer on the viability of milky-disease spores, the writer mixed standardized spore dust with a commercial fertilizer and applied it as a test treatment in cooperation with A. E. Rabbitt, of the National Park Service.

PROCEDURE.—A total of 24½ pounds of standardized spore dust containing 100 million spores per gram (more than 45 billion spores per pound) was thoroughly mixed with 400 pounds of a 10–6–4 commercial fertilizer on October 8. The mixture was rebagged and on October 10 was applied with a tractor-drawn fertilizer spreader to approximately 1 acre of turf in a strip 38 feet wide in the Mall area of Washington, D. C. Approximately 25 million spores per square foot were thus applied. Diggings in September and October of that year indicated that the larval population in the soil in this area averaged approximately 44 per square foot. Strips of grass bordering each side of the plot were left untreated as a check.

RESULTS.—Since the soil temperature was below that necessary for larval activity and spore development, no build-up of disease during the remainder of the 1940 season was expected.

Table 1.—Summary of survey data from a plot treated with milky-disease spore dust mixed with a commercial fertilizer. Dust applied on October 10, 1940.

	Larvae in Treated Area		Larvae in Untreated Area	
Date of Survey	Average Per Sq. Ft.	Per Cent Milky	Average Per Sq. Ft.	Per Cent Milky
1941				
August 5–8	22	11	26	0.4
September 2	16	34	21	0.5
October 27	7	52	11	1.0
1942				
May 20–22	6	17	12	1.0
June 1–4	2	70	6	23.0
August 18–20	7	38	—	—
October 26–30	2	30	4	10.0

Surveys made on May 6 and June 4, 1941, indicated an average of 27 larvae per square foot within the treated area and approximately 21 in the untreated check areas. No diseased larvae were recovered in the May survey, but in June gross examination indicated that 8 per cent of the larvae from the treated area showed symptoms of disease. The fact that infected larvae were generally found

throughout the treated plot indicated satisfactory distribution of the organism and that the fertilizer had little, if any, effect on the organism. No diseased larvae were recovered from the check strips at this time. Since approximately 57 per cent of the larval population was still in the third instar, the disease rate later in June should have been much higher. A limited survey was made on July 23, when more than half of the new brood were found to be eggs and the remainder very small first-instar larvae. In two square-foot diggings a total of 67 eggs and first-instar larvae were found.

Table 1 shows the reduction in the soil population and the build-up of disease on one brood of larvae in the treated plot and the check areas from August 1941 to June 1942, as well as the data from surveys made during August and October 1942, when a new brood was present in the soil. It can readily be seen that by October 1942 the soil population was exceedingly low and a large proportion of the larvae were diseased.

A survey during the first week of June 1943 showed an average of only 1 larva per square foot with one-third of the total population infected with milky disease. Subsequent observations continued to show a low population.

CONCLUSIONS.—Satisfactory distribution of the disease spores was obtained by means of a fertilizer spreader. Data from observations in a plot treated with a 10–6–4 commercial fertilizer mixed with milky-disease spore dust show no reduction in the viability of the disease organism due to the fertilizer. The results were about the same as usually obtained with the spot method of applying the spore dust. The data show rather conclusively that milky disease will reduce high larval populations of the Japanese beetle, and that the disease organism may spread rapidly to nearby untreated areas.—10-10-47.

Cameraria caryaefoliella, a Pest on Pecan

C. B. NICKELS, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The leaf miner *Cameraria caryaefoliella* (Clemens) attacks pecan in all the pecan growing states. Although it has been observed to cause considerable injury in southern Texas, it is ordinarily a pest of minor importance.

Leiby (1925) reported that this insect overwinters as a minute larva in a case 2 mm. long by 1 mm. wide, which is attached to the bud scales or to the trunk under pieces of loose bark, and that the larvae begin feeding as soon as the buds burst in the spring. At Crystal City, Texas, in 1941 many nearly full-grown larvae were observed on April 26 and again on October 25 and, in 1945, from April 23 to 30. The full-grown larva is light yellow and averages about 2.9 mm. long by 1 mm. wide. Moths emerged from collections at Crystal City in 1941 from May 18 to June 1, and in 1945 from June 15 to 24. In 1938 two moths emerged in August from a collection made at Blanco, Texas.

The larvae usually destroy the upper and middle layers of infested leaflets, but do not attack the lower layer. From 1 to 12 mines may occur per leaflet, and they may range from less than 2 mm. (fig. 2, A) to more than 25 mm. The mines are often partially transparent and are usually brown—dark in the center and lighter around the margin. Up to about 66 per cent of the leaflets have been found infested, and as much as 23 per cent of the area of infested leaflets has been found affected by the mines. Most mines contain only one larva, but a small percentage may contain 2, 3, or 4.

FIG. 1.—Stages of the leaf miner: A, Larva; B, adult, ×7.

The following parasites have been reared from the pecan leaf miner: *Chrysocharis* sp., *Eupelmus* sp., *Horismenus fraternus* (Fitch), *H. violaceus* (Ashm.), *Mirax* sp., *Paraleuroceras bicoloripes* Gir., *Pnigalio metacomet* (Cwfd.), and *Sympiesis nigripes* Ashm. All these parasites were identified by A. B. Gahan,

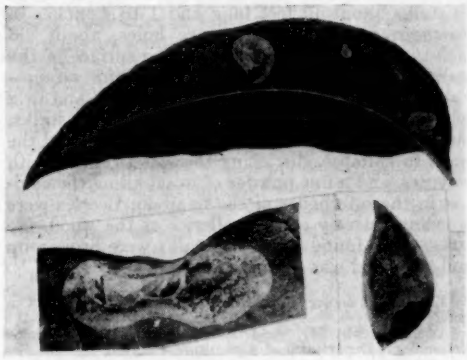

FIG. 2.—Leaf miner injury: A, Mines of leaf miner on pecan leaflet, ×1; B, pecan leaflet nearly covered by mine, ×1; C, Mine from which two moths had emerged, ×2½.

except *Mirax* sp., which was identified by C. F. W. Muesebeck. Slightly more than half the larvae collected June 8, 1945, were parasitized. The highest parasitism was by *Paraleuroceras bicoloripes*, *Pnigalio metacomet*, and *Horismenus fraternus*.—8-11-47.

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Alfalfa Weevil Damage to Onions and Beans

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The season of 1947 was one of unusually severe and extensive alfalfa weevil damage to alfalfa throughout Utah. Besides injury to the first crop, continuing weevil injury prevented new growth of second-crop alfalfa. The fields commonly remained brown and bare from 2 to more than 4 weeks after the first crop alfalfa was cut before the green growth again appeared and the second crop hay began to grow.

With such heavy alfalfa weevil populations, it was not surprising that some unusual situations were encountered. The most unexpected one occurred on July 7, when onion damage from weevils on a farm southwest of Honeyville was reported. The beetles brought in certainly appeared to be recently matured alfalfa weevils. They had literally riddled the onion leaves. Weevils were found both inside and outside the severely injured leaves which contained many holes of conspicuous size. Specimens sent to Washington were verified by L. L. Buchanan as *Hypera postica* (Gyll.). Severely injured pole-bean foliage and the beetles responsible also were brought in.

A visit was made to a farm, a few miles southwest of Honeyville, in Box Elder County. Hordes of recently matured alfalfa weevils were found around an alfalfa haystack. One large handful of litter, picked up two rods from the stack, contained approximately 380 weevils. On a small cocklebur plant near by approximately 350 adult weevils were clustered. Redroot pig weed foliage, *Amaranthus retroflexus*, had been severely skeletonized for several rods around the stack, and most of the plants were nearly dead. *Chenopodium album* and *Iva xanthiifolia* plants, on the other hand, harbored many weevils. An estimated 235 were present on the upper 5 inches of growth of a small marsh elder plant which showed no feeding injury. This plant was 20 feet from the haystack. A few weevils were present on sugar-beet foliage as far as 150 feet from the stack. At 150 feet from the stack, 175 adult weevils and a few larvae were taken in one sweep of the net in a badly weevil-injured corner of the nearest alfalfa field. Other single sweeps yielded 137 to 325 weevils in the area 150 to 165 feet from the stack. Farther away, weevil populations on the alfalfa decreased rapidly to average 2 per sweep at 200 feet and about one per sweep in mid-field.

The nearest edge of the onion patch was 45 feet from the haystack. The weevils always were present in conspicuous numbers when they were found to have attacked onions. An occasional onion top was severely damaged or in some cases only part of the top was destroyed, a few of the leaves remaining undamaged. Only 1 to 3 per cent of the onion plants in the field showed weevil-feeding injury.

An examination of the vegetable garden revealed a few alfalfa weevils on cucumbers and eggplant. Weevils were scarce on squash plants next to them. These plants were, in general, farther away from the haystack than were conspicuously damaged pole beans. The pole beans nearest the stack had from 2 to 15 per cent of the leaves severely eaten, curled, and dried out from adult alfalfa weevil injury. This end of the pole-bean rows was approximately 167 feet from the haystack. Damage to pole bean foliage was, at the time of the visit, unimportant at the far end of the rows, 200 feet from the haystack. From 3 up to 17 weevils usually were found within individual damaged and curled pole-bean leaves. Many weevils could be shaken into the insect net from undamaged and slightly damaged tops of the pole beans. Weevil injury was greatest to foliage on the lower third of the pole-bean plants.

Garden peas of several varieties were but slightly injured. An average of seven alfalfa weevils per square foot was shaken from the pea vines located a few feet nearer the haystack than were the nearest pole beans.

It appeared from the observations that under pressure of an extremely heavy population, adult alfalfa weevils will damage leaves of pole beans, onions, and *Amaranthus* pigweed. These adult weevils also feed to a limited extent on peas and some types of garden beans. The tendency of the weevils to congregate in large numbers on weeds on which they evidently did not feed was of interest.—10-20-47.

Empoasca filamenta Damage

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An extremely heavy infestation of small green leafhoppers was encountered on alfalfa at Moab, Utah, September 3, 1947, in a well shaded area. The presence of the leafhoppers was first noted from very conspicuous foliage spotting and discoloration. In this shaded area the active hopping of large numbers of green leafhoppers was noticeable, as they were disturbed by the writer as he walked through the more heavily infested section of the field. This was one of the highest populations and instances of severe injury which the writer had observed in Utah in which this particular species of leafhopper was concerned, other than occasionally on potato foliage.

Sweeping with an insect net yielded 12 to 20 leafhoppers, *Empoasca filamenta* DeLong, per sweep along one margin of this field in well shaded field margins beneath large cottonwood trees. The average number of leafhoppers per sweep of the net here was approximately 17. Out in the field, beyond the shade of the trees, the leafhopper population and alfalfa foliage injury was not conspicuous; here the leafhoppers averaged 1.2 per sweep of the net.

In this particular instance, it appeared that the shade afforded by the row of large cottonwood trees provided an especially favorable environment for this leafhopper, resulting in an unusual population concentration. The excessive amount of feeding due to such large numbers of leafhoppers resulted in the small individual feeding spots blending together, destroying large areas of chlorophyll in alfalfa along the heavily infested field margin. In this area the alfalfa was definitely off color and of shorter growth than that in unshaded portions of the field.

Empoasca filamenta occurs commonly in potato fields throughout Utah. Not infrequently it has caused obvious damage to potato foliage, particularly in late season. In addition it has been collected from foliage of beans, tomatoes, eggplants, peppers, cucumbers, squash, cantaloupes, sugar beets, celery, and white sweet clover.

Effect of Codling Moth Sprays on Natural Control of the Baker Mealybug

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The Baker mealybug, *Pseudococcus* sp.,[2] damages late varieties of pears grown in the Santa Clara Valley of California. Field tests on the biological control of the Baker mealybug were conducted during the 1947 season in a commercial planting of Winter Nelis pears which received a calyx and two cover sprays containing 1.5 pounds of 50 per cent DDT wettable powder. One block of 19 trees was left unsprayed throughout the season.

Fruit infestation, as measured by calyx colonies of mealybugs, continued to increase in the DDT sprayed plot until time of harvest. By contrast the infestation of fruit by mealybugs in tne unsprayed plot remained low throughout the season (Table 1).[3]

Table 1.—Percentage of fruit with calyx infestation on 60 fruits from six trees selected at random.

DATE	UNSPRAYED	DDT
July 9	0	6.7
July 15	0	10.0
July 21	0	8.3
July 30	1.7	6.7
Aug. 6	0	6.7
Aug. 13	0	8.3
Aug. 21	1.7	25.0
Aug. 25	5.0	40.0
Sept. 2	6.7	56.8
Sept. 8	5.0	60.0
Sept. 17	1.7	70.0
Sept. 23 (Harvest)	3.3	71.6

Although attempts were made to colonize the coccinellids, *Cryptolaemus montrouzieri* Muls. and *Scymnus binaevatus* Muls., the natural control of mealybugs obtained on unsprayed trees is attributed to the predaceous activities of *Chrysopa californica* Coq. It was quite evident that the increase in the mealybug population on sprayed trees was due to the suppression of the natural enemies. Furthermore the DDT residue remained so toxic to these beneficial insects that their return to the sprayed orchard was prevented for several months during the period when the mealybugs were most active. The extent to which *Chrysopa californica* was deterred in sprayed areas is shown in table 2. Furthermore the effect of *Chrysopa* suppression is made apparent by comparing the number of mealybugs trapped on sprayed and unsprayed trees (Table 2).

The above field data suggest that the DDT residue remains lethal to beneficial insects over a long period and may serve as an effective barrier to the mealybug enemies throughout a season. Further evidence on the length of time field applied and weathered DDT remained toxic to entomophagous insects was obtained by using *Scymnus binaevatus* as a test insect.

[1] Junior Entomologist in the Experiment Station.

[2] The taxonomy of the so-called "*maritimus* complex" is so uncertain that it seems best not to apply the name *P. maritimus* to this species at this time.

[3] Data collected with the assistance of K. S. Hagen, Senior laboratory technician.

Table 2.—Mealybugs and predators trapped in bands on six sprayed and six unsprayed trees.

DATE	UNSPRAYED		DDT	
	Mealybug	*Chrysopa*	Mealybug	Chrysopa
July 9	3	2	63	0
July 15	5	2	61	0
July 21	3	5	50	0
July 30	0	24	40	0
Aug. 6	0	36	66	5
Aug. 13	0	18	60	4
Aug. 21	0	30	61	1
Aug. 25	0	8	75	5
Sept. 2	0	5	74	4
Sept. 8	1	0	59	1
Sept. 17	1	2	45	0
Sept. 23	6	2	59	0

Weekly samples of foliage and bark were collected in the field and taken to the laboratory where *S. binaevatus* adults were confined with them. The amount of time that elapsed before 100 per cent mortality occurred is recorded in table 3. It is interesting to note that DDT remaining on the foliage was capable of killing all test insects within 24 hours, even though it had weathered in the field for 4 months.

Table 3.—DDT residue toxicity tests on twenty adult *Scymnus binaevatus* confined with samples.

DATE OF SAMPLE	NUMBER OF DAYS ELAPSED BEFORE 100 PER CENT MORTALITY			
	Unsprayed Foliage	Unsprayed Bark	DDT Bark	DDT Foliage
July 15	10	4	4	2
July 22	6	6	3	2
July 30	6	6	3	2
Aug. 8	4	4	4	1
Aug. 13	—	6	3	2
Aug. 21	5	4	3	1
Aug. 25	5	4	3	1
Sept. 2	4	4	2	1
Sept. 8	6	6	5	2
Sept. 17	3	3	3	1
Sept. 23	6	4	3	1

There can be little doubt that entomophagous insects are capable of being a very effective check on mealybugs on pears. At the same time the most effective codling moth control offered is the use of DDT. While the two controls seem superficially to be incompatible, there is actually good reason to believe that they could be used effectively together. It is very probable that satisfactory codling moth control may be obtained by a reduction in the number of DDT sprays, and present research indicates that natural enemies of mealybugs can be produced cheaply and in quantity. Under these conditions it appears that the use of biological control of mealybug infestations as a supplement to the DDT program for codling moth is both practical and desirable.

SUMMARY:—Data collected during the 1947 sea-

son show conclusively that severe infestations of the Baker mealybug on pears are correlated with the application of DDT and the suppression of natural enemies. Field tests showed that *Chrysopa californica* was able to destroy mealybug populations and hold them under natural control in the absence of insecticidal sprays. The long period during which DDT residue remains lethal to beneficial insects was determined by tests on *Scymnus binaevatus*.

Comparative Toxicity of Nicotine, Nornicotine and Anabasine to Green Peach Aphid

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With an American source of anabasine from *Nicotiana glauca* Grah. available, and the eventual return of the Russian product to the American market probable, it is desirable that further entomological testing be done with pure materials. A review of the literature shows that the testing of anabasine sulfate against the green peach aphid, *Myzus persicae* (Sulz.), has been reported by Garman (1933, 1934), Skalov (1934), Savchenko & Dzevaltovskaya (1937), and Vavilov & Mukhitdinova (1935). A concentration of 1 to 1000 was reported by Garman & Skalov as giving good clean-up of this insect, but lower concentrations were "insufficient in combating this insect."

These results were obtained with commercial anabasine sulfate made from *Anabasis aphylla*. Smith (1932) found that considerable methylanabasine was also present in commercial anabasine sulfate, and Dashkevich (1939) stated that only 21.52 per cent of anabasine and varying percentages of other alkaloids were present in the commercial product. Since nornicotine has been found to occur along with nicotine in commercial nicotine, and in nicotine products and tobacco much more commonly than was previously believed, comparative tests of nicotine and nornicotine should also be made. In the absence of any reported tests of the comparative toxicity of these three alkaloids (anabasine, nicotine, and nornicotine) to the green peach aphid, a preliminary study of the insecticidal value of the aqueous alkaloid solutions was undertaken.

Leaves infested with the green peach aphid were cut from potted cabbage plants, and the cut ends of the stems placed in bottles of water to keep the foliage alive for the duration of the experiment. Each bottle containing a leaf was then placed in a shallow white-enameled pan about 12 inches in diameter, the upper rim of which was coated with either tanglefoot or vaseline to prevent the apids from escaping. The alkaloid solutions were applied with an electrically operated compressed-air sprayer. The leaves were kept in a greenhouse for the first half-hour after treatment, and then transferred to the laboratory to avoid the effects of bright sunlight on the aphids. Within the first half-hour large numbers of aphids became affected and dropped from the leaves into the pans. The final mortality counts were made 24 hours after treatment.

Each alkaloid solution was prepared so as to be free from the other alkaloids (Siegler & Bowen 1946). In tests with a 0.20-per cent solution of each alkaloid, both with and without a wetting agent (sodium lauryl sulfate 1:1000), a very high kill (98 to 100 per cent) of all stages resulted. Concentrations of 0.05 per cent, with and without the same wetting agent, gave only slightly lower mortalities. The results obtained at these concentrations seem to indicate that the three alkaloids are of equal toxicity. In further tests a greater dilution of each material (0.025 per cent or 1:4000) was used, with and without the wetting agent, with the results shown in table 1.

Table 1.—Mortality of green peach aphids caused by sprays containing 0.025 per cent of nicotine, nornicotine, and anabasine.

Materials	Without Wetting Agent		With Wetting Agent	
	Number of Insects	Per Cent Mortality	Number of Insects	Per Cent Mortality
Nicotine	270	52	766	74
Nornicotine	417	90	402	86
Anabasine	732	95	755	90
Water+wetting agent	—	—	382	0.8
Untreated check	230	1.7	—	—

It is evident that both anabasine and nornicotine are considerably more toxic than nicotine to the green peach aphid, when these materials are used at a concentration of 0.025 per cent. When used with a wetting agent, a slight decrease in toxicity of nornicotine and anabasine was noted, while the toxicity of nicotine showed a marked increase. Further investigation of the cause of this behavior is planned.

No plant injury due to the insecticide was observed.—12-11-47.

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Parathion for Control of the Two-Spotted Mite and Certain Insects

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The authors tested parathion, O,O-diethyl-O-p-nitrophenyl thiophosphate,[2] under field conditions for the control of the common two-spotted mite, *Tetranychus bimaculatus*, Harvey; pear thrips, *Taeniothrips inconsequens*, Uzel; black peach aphid, *Anuraphis persicae-niger*, Smith; and the cherry fruit fly, *Rhagoletis cingulata*, Loew, under laboratory conditions.

It was applied as a dust for two-spotted mite control on field plots of lima beans on September 11, to 100 gallons of spray, 100 per cent; hexa-ethyl-tetra-phosphate, 1–800, 100 per cent; 5 per cent DDT dust, 77.4 per cent; 25 per cent DDT in oil emulsion 2 quarts, water to make 100 gallons of spray, 87.8 per cent; 2 per cent chlordan dust, 18.5 per cent; nicotine sulfate, 40 per cent, 1 to 800, 88.1 per cent; untreated plot, 4.1 per cent.

Parathion dust at 0.25 per cent was tested for toxicity against the cherry fruit fly under laboratory conditions. Each test was replicated six times. Fifty per cent mortality occurred in 14 hours in one test, in 23 hours in two tests, and in from 24 to 30 hours in the remaining tests. Mortality of 100 per cent occurred in 36 hours in two tests and in 68 hours in the remaining four tests.—1-2-48.

Table 1.—Effect of parathion on the two-spotted spider mite.

Concentration of Parathion	Sept. 13			Sept. 17			Sept. 27		
	Live	Dead	% Dead	Live	Dead	% Dead	Live	Dead	% Dead
0.125% dust	30	76.8	71.9	23	66.8	74.3	61	29.6	36.7
0.25% dust	6.6	90.1	93.1	44	55.6	55.8	110	26.5	19.4
Average of 3 check plots	149	3.7	2.4	104	26.4	20.2	178	19.7	9.9

with a small, single row, hooded power duster at the rate of 40 pounds per acre. The row plots were five yards long. Results were determined by counting mites on six one square inch samples taken from the bottom side of the apical leaflet of bean leaves. The samples were taken at random in the plot. A binocular microscope was used to determine the live and dead mites. Table 1 gives the average mite count per square inch of leaf sample.

Results indicate that parathion when used at .25 per cent dust was effective two days after dusting, but apparently lost its effect by 16 days later.

A .25 per cent parathion dust was tested for the control of pear thrips on prunes in one Italian prune orchard. One plot five trees long and four trees wide was dusted for adult thrips control. A plot of similar size was used as a control plot. Results were determined by population counts taken immediately before dusting and one day after.

The reduction in the parathion dusted plot was 84.7 per cent. The control plot showed no reduction.

Parathion was used at the same concentration for black peach aphid control. Its effectiveness was compared with six materials. Two heavily infested peach trees were used in each test. Two terminal twigs 8 inches long, which included two leaves were taken from each peach tree one day after treatment. The aphids were observed under a binocular microscope and the live and dead aphids separated.

Results obtained based on percentage of dead aphids were as follows: .25 per cent parathion dust, 98.5 per cent; 10 per cent DDT dust, 76.7 per cent; benzene hexachloride, 12 per cent gamma, 3 pounds

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[2] This insecticide was provided through the courtesy of the American Cyanamid Company, New York.

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Control of Codling Moth on Pears with a DDT Spray

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The conventional method of spraying deciduous fruit trees for the control of insects and plant diseases requires the application of large volumes of spray materials and adds greatly to the cost of production of deciduous fruits. As a means of reducing this cost, the use of concentrate sprays in the newer types of equipment offers an opportunity to effect a saving in labor, materials and equipment.

In the control of codling moth on apples and pears n California the use of 50 per cent DDT wettable powder has given excellent results in fewer applications than was required with lead arsenate but the pear growers are still confronted with the problem of handling large volumes of spray solutions and the attendant labor and equipment expense. The newer types of spray equipment (such as the *Speed Sprayer*) which use a large volume of air as a carrier for the spray solutions have materially reduced the aborl and time factors of bulk spraying and apparently offer the opportunity further to reduce costs when used for concentrate sprays. During the 1947 season a 30-acre experimental plot was employed in testing this method for the control of codling moth on Bartlett pears. This orchard had been sprayed the previous season with lead arsenate and at harvest in 1946 had shown a rather high percentage of wormy fruit.

The material used this season was a DDT concentrate prepared from technical DDT, a suitable solvent and an emulsifier. The emulsion contained 36 per cent DDT and was diluted in the spray tank at dosages of 3 gallons and 6 gallons of concentrate per 500 gallons of water. One-half of the plot received the 8-gallon dosage and the other half the 6-gallon

dosage. Three applications were made—the first April 2 (when all of the petals were off), the second April 16 and the third May 2. The fruit was harvested August 1 and 2.

The equipment used was a *Speed Sprayer* on which only two rows of jets were left open and every other jet was blocked out in each row. This left but 45 jets in operation and the jet opening was reduced to .05 inch. This produced a very finely divided mist with sufficient velocity to carry through and over the tallest trees. The equipment was drawn at a speed of not over 0.8 mile per hour down each tree space and thus covered both sides of each tree row. The amount of material applied per tree averaged about 2 gallons and it took 60 to 75 minutes to empty each 500-gallon tank of diluted spray. The visual deposit of spray on the foliage and fruit was a uniform distribution of very fine round beads of spray solution which did not coalesce or form large droplets. Due to the fine droplet size and the small amount applied per tree there was practically no drip or run-off. Deposit studies were made after the first application, before and after the second and third applications and at harvest, by taking 50 random samples of fruit and analyzing for DDT. Due to the small size of the fruit after the first application only the total deposit (2.63 mgs. per 50 fruits) was determined. The other analysis showed the following deposits:

DDT deposits (ppm) on pears sprayed with 3 gallons concentrate spray per 500 gallons of water

	Before	*After*
Second application (April 16)	5.4	20.2
Third application (May 2)	3.4	10.0
At harvest—July 1	0.09	

Adequate sampling of the harvested fruit showed not a single codling moth worm entry in either block of fruit. No injury to fruit or foliage was noted at any time during the season.

In this orchard not only has this method shown a reduction in the labor and equipment requirements for applying sprays for codling moth control but it has also reduced the material cost of each spray application from approximately $16.83 per acre for bulk spraying to $2.03 per acre for the concentrate sprays. Though this method should not be attempted until the proper type of equipment is available, it apparently offers one of the most promising means of reducing the cost of spray applications.—9-15-47.

Secondary Parasites of the Oriental Fruit Moth Through *Macrocentrus ancylivorus*

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The primary parasites of the oriental fruit moth, *Grapholitha molesta* Busck, are in turn attacked by secondary parasites. Stearns (1928), Haeussler (1930), McConnell (1932), and Garman (1940) listed several species of secondary parasites that have been reared from oriental fruit moth parasites, although no data were presented on the degree of parasitization or the species that they attack. In 1940 and 1945 observations were made in peach orchards in the vicinity of Moorestown, N. J., to determine the effect of secondary parasites of the oriental fruit moth on *Macrocentrus ancylivorus* Roh.

The parasitized oriental fruit moth larvae used in these observations were obtained by collecting infested peach twigs from nearby orchards. The infested twigs were placed with small green apples for the immature larvae to feed in and corrugated cardboard strips for the mature larvae to cocoon in. The trees on which cocoons were placed were five trees apart in the orchards. One cocoon, inside a cardboard corrugation, was pinned to the trunk and one to each major limb, about half way between the trunk of the tree and the first lateral branches. The cocoons were allowed to remain on the trees for 11 days. They were then removed from the trees, placed in individual vials, and held at normal temperature for emergence. In 1940 larvae in cocoons were placed in four orchards on June 14. In 1945 the cocoons were placed in five orchards on June 16. These exposures were made during the time that first-brood oriental fruit moth cocoons were present in orchards.

A total of 383 oriental fruit moth cocoons bearing larvae that had been parasitized by *Macrocentrus ancylivorus* were exposed to secondary parasite attack, 162 in 1940 and 221 in 1945. Secondary parasites parasitized 68.7 per cent of the *M. ancylivorus* exposed. Parasitization by secondary parasites in four orchards in 1940 ranged from 44.7 to 76.5 per cent, and in five orchards in 1945 from 57.7 to 100 per cent. The species of secondary parasites reared and the percentage of parasitization caused by each are given below.

Secondary parasite	Per Cent Parasitization of *M. ancylivorus* 1940	1945
Arachnophaga frontalis Gah.	9.3	7.2
Coccygomimus inflatus (Townes)	0.6	0.5
Dibrachys cavus (Walk.)	31.5	20.8
Encyrtaspis semirufus Gah.	1.2	—
Eupelmus spongipartus Foerst.	3.1	7.7
Eupelmus cyaniceps v. *amicus* Gir.	—	0.5
Eurytoma appendigaster (Swed.)	6.8	32.6
Gelis tenellus (Say)	3.1	1.4
Mastrus pilifrons (Prov.)	0.6	0.5
Sp. (dead in *M. ancylivorus* cocoons)	2.5	5.0
Total	58.7	76.2

Although these observations were restricted to the first brood of oriental fruit moth and of cocoons placed on trees, the results obtained are indicative of the extent of secondary parasite attack on *Macrocentrus ancylivorus* in peach orchards. This beneficial parasite is not singular in having a number of parasites attack it, as all parasites are limited in population by a number of factors, one of which is, usually, secondary parasites. Despite its restriction in population it parasitizes a high percentage of oriental fruit moth larvae, especially the second brood, in orchards in New Jersey and many other States where peaches are grown.

The effectiveness of mass liberations of *Macrocentrus ancylivorus* to reduce oriental fruit moth infestations in ripe peaches has been shown by Brunson (1940) and Brunson and Allen (1944). Since this parasite attacks its host while it is feeding in twigs, it could be liberated on both the first and second broods of the host. Mass liberations on first-brood larvae in southern New Jersey have not resulted in a

significant reduction in ripe-fruit infestations, but excellent results have been obtained from liberations on second brood. In view of these observations it is indicated that attack by secondary parasites may be one of the causes of poor results from liberations on the first brood.

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Further Studies with Sulfathiazole for Control of Foulbrood

LEONARD HASEMAN

At the Dallas meeting of the Association I gave a preliminary report on our investigations of certain sulfonamides for controlling American foulbrood of bees. In summarizing our results I pointed out at that time that from our previous three years of research we were convinced that sulfathiazole fed to bees either in sugar syrup or in pollen substitute was an effective control for American foulbrood, that it was effective either in protecting healthy colonies against becoming infected or in enabling infected colonies to clean their combs of all evidence of the disease and to use them for rearing normal, healthy brood.

Since that report was given we have made some further progress in our studies on the use of sulfa drugs and other bacterial inhibitors, though I have at this time no new startling developments to report. Most of what will be given pertains rather to our attempts and those of others to simplify and to improve on the use of sulfathiazole.

In 1946 we included in our experiments also penicillin and streptomycin and the more soluble sodium sulfathiazole. In a small number of tests the sodium sulfathiazole gave us substantially the same results as did the regular sulfathiazole, though we used it at twice the concentration or in approximately a 30 milligrams per cent solution. Our work with the two antibiotics, streptomycin and penicillin, indicated that they can be used in somewhat the same way as we have been feeding the sulfa drugs and with similar results if one is in position to handle them as carefully as medical men use them in hospitals or in the laboratory. However, we soon got contamination into our materials which spoiled them for further use. Our beekeepers at present are just not in position to handle these materials as they must be handled to get results. However, the bacteriologists in the Merck and the Lederle laboratories, who have kindly cooperated in making laboratory studies on the effect of sulfa drugs and antibiotics on *Bacillus larvae*, have found that these two antibiotics are far more effective in inhibiting vegetative growth of this bacillus than are the sulfa drugs.

In 1947 along with further studies on the sulfonamides we began some preliminary work with one of the hormones and the results secured justify further investigations with different hormones and also with vitamines. While in these studies we are primarily interested in developing a simple, effective and foolproof control for American foulbrood, there are other bee ailments still poorly understood and there are so many other unsolved problems about the honeybee and how it does the things it does that we plan to expand this study to include some of these other fields.

In the way of improvement in the method of feeding the sulfa drugs we believe that we now have a practical method of quickly feeding it in sugar syrup to even the large commercial apiaries. By means of a portable compressed air sprayer with small angled nozzle we can spray the solution through the entrance up into the brood combs without opening the hive and in this way we can feed large numbers of colonies every few days with a minimum of labor and time. In fact this will permit the feeding of colonies even after they are prepared for the winter or early in the spring before the winter seal can safely be broken. By this method entire commercial apiaries can be treated at very small expense and with measured dosages given to each individual colony.

Along with our apiary studies this past summer we also enlisted the interest and help of our medical bacteriology department in undertaking laboratory studies to try and find out how the sulfa drugs fed to the bees finally reach and protect the young brood during its short period of susceptibility to the action of the disease germs. They are also interested in studying the reaction of the bacillus to varying concentrations of the sulfa drugs and the antibiotics. If and when they find out all they hope to learn from their laboratory studies we may be able to say with more certainty how the treatment actually protects the brood and also whether or not the treatment is a complete cure or merely a temporary clean-up with fortification against reinfection.

Tests with DDT, Benzene Hexachloride and *Ryania* for Pink Bollworm Control

O. T. ROBERTSON, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

The results of small field-plot and cage tests with various insecticides for the control of the pink bollworm, *Pectinophora gossypiella* (Saund.), at Presidio Tex., during 1946 are briefly discussed herein.

SMALL-PLOT TESTS.—Technical DDT at 5-, 10- and 20-per cent strengths in pyrophyllite was applied at various rates per acre in 0.2-acre plots, each treatment replicated twice in a randomized block.

[1] In cooperation with the Texas Agricultural Experiment Station.

Five applications were made to each plot with single-nozzle rotary hand dust guns early in the morning, when the air was generally calm and the plants were occasionally damp with dew. The results are based on three infestation counts made at biweekly intervals from September 9 to October 22.

The per cent control in the green-boll infestation was directly proportional to the total amount of DDT applied per acre (table 1). The control for the season ranged from 9 per cent with 3.8 pounds per acre to 57 per cent with 17.5 pounds.

Table 1.—Effects of various concentrations of DDT in pyrophyllite applied at different rates per acre at weekly intervals for pink bollworm control, Presidio, Tex. 1946. [5 applications, average of 2 plots.]

Per Cent of DDT	Pounds of Mixture Per Acre-application	Total Pounds of DDT Applied	Seasonal Average Infestation		Per Cent Control
			Per Cent of Bolls Infested	Number of Mines Per Boll	
5	15.2	3.8	93	6.58	12
10	7.7	3.8	90	6.77	9
	11.8	5.9	89	6.19	17
20	10.5	10.5	84	4.86	35
	17.5	17.5	69	3.16	57
Check, no treatment	—	—	97	7.47	—

Additional tests were conducted comparing 1.43, 2.87, and 5.75 per cent of gamma isomer of benzene hexachloride in sulfur, 50 per cent of *Ryania* powder in sulfur, and 10 per cent of DDT in pyrophyllite. The DDT gave somewhat better control than any of the other materials.

CAGE TESTS.—Tests comparing a dust and a spray containing DDT were conducted under a field cage covering 0.55 acre. The cage was divided into three equal sections, one for each treatment and a check, by screen partitions to prevent moth migration between treatments.

The dust contained 10 per cent of DDT in pyrophyllite, and it was applied with a single-nozzle hand gun at the rate of 26.3 pounds per acre-application.

For the spray 0.4 pound of technical DDT was dissolved in 0.75 pint of xylene and then further diluted with water, 15 ml. of a polyether alcohol condensate, being used per gallon of finished spray as the emulsion. A knapsack-type hand sprayer equipped with a tangential nozzle that delivered about 4.25 gallons of spray per acre was used for applying the insecticide. The emulsion was applied at the rate of about 10 gallons or 2.69 pounds of technical DDT per acre-application.

Eleven applications of each treatment were made commencing 6 days before the first bloom, or on June 4, and continued at weekly intervals until green bolls became scarce, or on August 12.

There was no significant difference in the control obtained with DDT dust and DDT spray (Table 2). There was a reduction of 90 to 93 per cent in the bloom infestation and 99 per cent in mines per boll from both treatments. A gain of about 900 pounds of seed cotton per acre was obtained from each treatment and the lint was classified as Good, Middling, Extra, and White with a staple length of 1.12 inches. The cotton in a check plot maintained in these tests was almost completely destroyed; it produced 351 pounds of seed cotton per acre and the lint was classified as good, ordinary, irregular, weak, and wasty with a staple length of 0.8 inch.

Table 2.—Results of tests under field cage with DDT dust and DDT spray applied at weekly intervals (11 applications) for pink bollworm control, Presidio, Tex., 1946.

Treatment	Pounds of DDT Per Acre-application	Average Seasonal Infestation			Pounds of Seed Cotton Per Acre	
		Per Cent of Blooms Infested	Per Cent of Bolls Infested	Number of Mines Per Boll	Yield	Gain Over Check
Dust	2.63	3	7	0.12	1240	898
Spray	2.69	4	5	0.08	1274	923
Check	—	38	100	16.99	351	—

The residual effect of DDT was probably greater under the cage than in the field, owing to shade; and the screened partitions prevented any influx of moths from untreated areas. For these reasons it was believed that the control obtained under the cage was considerably higher than would be possible under field conditions. The application of about 29 pounds of DDT in both treatments during the season prevented any damage.

In tests where several plants were dusted with 10 per cent of DDT in pyrophyllite at the rate of about 20 pounds per acre and immediately caged with 50 pairs of moths per cage, there was a reduction of 88 per cent in oviposition as compared with the check.

In another test 50 pairs of moths were caged on plants, and after 4 days, or before any of the eggs hatched, the cages were removed and the plants dusted with 10 per cent of DDT in pyrophyllite at the rate of about 20 pounds per acre. An examination of the bolls 12 days after treatment showed a reduction of only 8 per cent in the number of larvae per boll. These tests indicate that the control from DDT dust is obtained in the field principally by moth mortality rather than by mortality of newly hatched larvae.

Collecting and Counting Onion Thrips from Samples of Vegetation

F. H. SHIRCK, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1,2]

With the initiation of a research program on the control of onion thrips, *Thrips tabaci* Lind. in southern Idaho, it became desirable to adopt some standard procedure for estimating thrips populations. Examination of the literature showed much diversity in the sampling methods used. Thrips are difficult to collect and count because of their small size and their tendency to escape or hide, and also because of the tremendous variation in the intensity of infestations. Many workers, particularly those concerned with estimating thrips populations on onions, have failed to give details of their methods. McGregor (1926) collected citrus thrips by striking the

[1] The writer acknowledges helpful criticisms and suggestions given by J. R. Douglass, under whose direction this work was conducted. Thanks are due to H. C. Hallock and W. C. Cook for suggestions, to D. E. Fox for assistance with some of the preliminary tests, and to F. R. Lawson for assistance with the counts and suggestions for improving the counting apparatus.

[2] The project on thrips control is carried on in cooperation with the Idaho Agricultural Experiment Station, and thanks are due H. C. Manis of that station for reviewing this manuscript.

branches against a hardware-cloth screen over a sheet of black paper covered with a tanglefoot preparation. The thrips were caught on the sticky sheets and counted in the field. Watts (1936) developed a Berlese-type funnel equipped with a hot-water jacket for heating samples of vegetation to stimulate emergence of thrips. Bondy (1940) used a Berlese-type funnel exposed to direct sunlight for collecting thrips from samples of cotton plants.

METHODS.—It was decided to try the Berlese-funnel method. The first trials with wide metal funnels exposed in the sun as described by Bondy were unsuccessful. The onion foliage dried too slowly, and excessive numbers of very small thrips larvae indicated that hatching occurred while the samples were drying. After some experimentation with artificial temperatures, it was found that thrips could withstand exposure to 115° F. without injury, and that this temperature would cause them to leave the onion samples.

Apparatus used in collecting and drying onion samples and counting thrips is shown in figure 1. A cardboard cylinder of 4-ply plain 030 jute tubing is used as a sample container and as a cover for the assembled drying unit (fig. 1, *A*). The cylinder is 7 inches high and $5\frac{3}{8}$ inches in outside diameter, and is permanently closed at one end by a cloth cover glued in place.

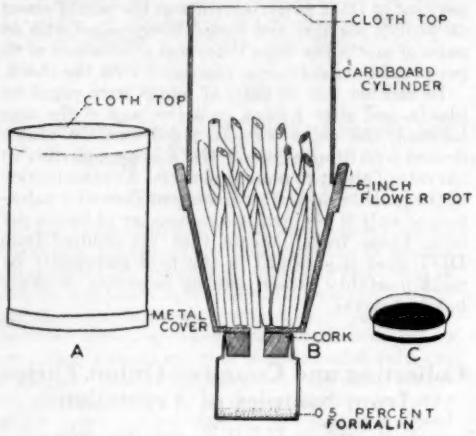

FIG. 1.—Articles used in making thrips counts: *A*, Cardboard cylinder for collecting samples; *B*, unit assembled for drying sample of onions, with cylinder in place as a cover; *C*, counting device prepared by stitching white guide lines on black cloth and cementing the cloth to a metal ring.

Only the 7-inch basal section of the onion plant is used. This section contains a large proportion of the thrips, and is of especial interest in control investigations because of the difficulty experienced in securing penetration of insecticides into the leaf axils. The sample of onion plants is cut off above the bulbs, the butt ends are thrust into the cylinder, and the portion of the leaves projecting beyond the cylinder is cut off and discarded. The cylinder is then closed with the metal cover and taken to the laboratory for drying.

In preparing the sample for drying the metal cover is removed, and the open end of the cylinder is thrust into a 6-inch flower pot, which serves as a drying funnel. A 2-inch cork with a half-inch hole through its center is glued to the bottom of the pot so that the hole in the cork corresponds with the hole in the pot. The cork provides a tight connection with a half pint fruit jar used to collect the thrips as they leave the pot. Tight-fitting metal funnels were first used, but the flower pots were fully as efficient. The assembled unit is shown in figure 1, *B*.

Sometimes a few dead thrips are found in the bottoms of the flower pots, and these are emptied into the collection jars before counts are made. The thrips fall into a small amount of 0.5 per cent formalin solution, which preserves them until counts are made. The liquid in the jar is strained through a counting device shown in figure 1, *C*. The counting device is then set on an absorbent pad to draw out the excess liquid remaining in the cloth, and the counting is done under binoculars. In very heavily infested samples the liquid is made up to 1000 ml., and the thrips in a 100-ml. aliquot are counted.

TESTS UNDER CONTROLLED TEMPERATURES.—A test was conducted to determine the exposure period required to drive thrips from onion samples at different temperatures. Twenty samples of 10 onion plants each were exposed simultaneously to constant temperatures of 105°, 110°, 115°, 120°, and 125° F. The temperature cabinets described by Annand & Harries (1940) were used. The collection jars were replaced by fresh jars, and thrips counts made at 4-hour intervals for the first 32 hours and at 8-hour intervals thereafter until the end of 96 hours of drying. The data obtained in this test are given in figure 2.

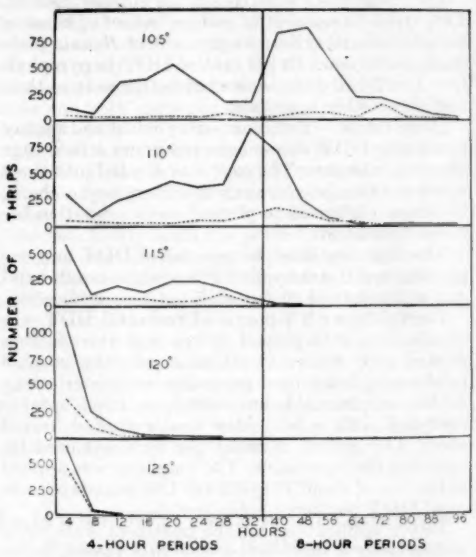

FIG. 2.—Rate of emergence of thrips from samples of onion plants at different constant temperatures (°F.). Solid lines show emerging larvae; broken lines show adults.

At temperatures of 105° and 110° F. too long a period was required to collect the thrips, and there were indications that hatching occurred while the samples were drying.

At 115° F. a heavy emergence of larvae occurred during the first 4-hour period, after which the movement out of the samples was more gradual. After 32 hours' exposure very few larvae were recovered. The

adults also showed a definite tolerance for the 115° temperature, since the adult movement from the samples did not reach a peak until the 28-hour count. The total number of thrips obtained at this temperature showed a sharp drop from the totals obtained at 105° and 110°. However, the counts were probably nearer the actual population on the plants when samples were gathered, since apparently little, if any, hatching took place while the samples were being dried.

The chart shows a distinctly different type of curve for 120° and 125° F. than for the three lower temperatures. Evidently the thrips found these higher temperatures unsatisfactory, since they rapidly left the samples. Emergence was 92 per cent complete at 120° and 96 per cent complete at 125° in the first 8 hours. At 115° a total of 2078 larvae and adults was obtained, while at 120° the total was 1919. These totals were not significantly different. The total of larvae and adults at 125° was 1,232, a number significantly lower than the totals at 115° and 120°. Evidently 125° was too high, since it caused the death of approximately 50 per cent of the larvae before they left the samples. The number of adults obtained was not significantly different at the five temperatures.

Two later tests were made to compare results at 115° and 120° F. Samples of 100 onion plants were kept for a continuous 24-hour period at each temperature. The total number of thrips obtained for each of the respective tests was 2768 and 1223 at 115°; 527 and 624 at 120°.

DISCUSSION.—An adaptation of the Berlese-funnel method has been found satisfactory for collecting thrips from samples of onions as well as from other vegetation. The samples are subjected to heat and drying in a temperature cabinet, which treatment causes the thrips to emerge into collection jars attached to the sample-drying units. For onions, a drying period of 24 hours at 115° F. has been used. Figure 2 indicates that a shorter drying period at 120° would be sufficient; however, later trials at these two temperatures showed a definitely higher recovery of thrips at 115° than at 120° after a continuous drying period of 24 hours.

High temperature within the range 100° to 125° F. is believed to be the primary cause of the thrips' leaving the samples. Low humidity causes rapid wilting of the vegetation and thus hastens the movement of the thrips. The effect of humidity is rather difficult to evaluate, since the humidity inside the individual sample-drying unit is not necessarily the same as that inside the cabinet.

This method has the following advantages: (1) A large number of samples can be handled at a time, and counts can be made rapidly; (2) if counting cannot be done at once, the jars can be set aside until later; (3) only thrips that are alive and able to leave the samples are counted. Examinations to determine the number of thrips remaining on onion plants after 24 hours' drying at 115° F. have shown only a few thrips, most of which were dead.

This method has also been successfully used for estimating thrips populations on onion seed heads, and on alfalfa, clover, bean, and pea plants. On types of vegetation that wilt readily a drying temperature as low as 110° F. may be used.

A simple drying cabinet provided with a heating element or heated with electric-light bulbs has been found to give satisfactory results. Thrips seem to leave the samples equally well whether the cabinet is well-lighted or completely dark. An inexpensive thermostat is needed to keep the temperature from becoming too high, and a small electric fan inside the cabinet to force circulation of air is useful.

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Control of the Northern Fowl Mite[1]

P. O. RITCHER and W. M. INSKO, JR., *Kentucky Agricultural Experiment Station, Lexington*

Discovery of a heavy infestation of the northern fowl mite, *Liponyssus silviarum* (C. & F.),[2] among roosters at the Station poultry farm in January, 1947, offered an opportunity to try out various methods of control. Materials tested are 40 per cent nicotine sulfate applied to the birds by the drop method, sodium fluoride powder, 10 per cent *Lethane* powder, 5 per cent DDT powder, 10 per cent sabadilla powder, and benzene hexachloride powder (.5 per cent gamma isomer content).

Sixteen cull roosters, all heavily infested with all stages of mites and many eggs, were isolated in an egg-laying battery on January 22, 1947. At that time four materials, 40 per cent nicotine sulphate (4 drops), sodium fluoride powder, 10 per cent *Lethane A-70* powder, and 5 per cent DDT powder were each applied to 4 birds chosen at random. A medicine dropper was used to apply the 40 per cent nicotine sulphate, one drop being applied an inch below the vent, another on the back of the head and one drop under each wing. Four pinches of each powder were applied to the same regions using an average amount of 3.95 grams of sodium fluoride, 2.67 grams of *Lethane A-70* and 2.67 grams of 5 per cent DDT powder per bird.

Examination of the roosters 5 days later on January 27 showed that mites had been eliminated completely only on the birds treated with nicotine sulphate (Table 1). Mite populations present on the birds were rated on a scale of 1 to 10 with 1 indicating that at least 1 live mite was seen, 2 indicating that a very few (3–5) mites were seen and so on up to 10, which would apply to very heavy infestations. Also on January 27 feathers from all treated birds were examined microscopically and it was found that although mite eggs had continued to hatch following treatment the newly hatched mites had soon succumbed. A few viable eggs were found on one rooster treated with 5 per cent DDT.

By February 28, a month later, mites had become so numerous on many of the roosters treated with materials other than nicotine sulphate that it was

[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

[2] Identification of this mite was confirmed by E. W. Baker of the Division of Insect Identification, U. S. National Museum.

Table 1.—A comparison of the northern fowl mite populations on roosters following treatment January 22, 1947 with 40 per cent nicotine sulfate, sodium fluoride, *Lethane A-70* and 5 per cent DDT. Infestation rated on a scale of 1 to 10.

Date	Nicotine Sulfate Rooster No.				Sodium Fluoride Rooster No.				Lethane A-70 Rooster No.				5% DDT Rooster No.			
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
January 27	0	0	0	0	2	2	1	1	1	0	1	1	2	1	4	4
February 11	0	0	0	0	1	1	2	2	3	1	3	3	4	0	1	6
28	0	1	0	0	8	5	7	10	10	7	10	6	7	2	3	3
28					Treated again				Treated again				Treated again			
March 7	0	0	0	0	0	1	0	1	0	0	1	0	2	1	0	0
14	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0
21	0	0	0	0	1	1	2	0	2	0	4	0	3	0	0	2
31	0	2	1	0	2	1	2	1	3	1	10	0	6	1	2	1
April 11	0	2	1	1	2	3	3	3	8	2	10	1	8	2	4	2

decided to retreat the birds dusted previously with sodium fluoride, *Lethane A-70* and DDT using the same materials but in much larger quantity. This time 8 generous pinches of powder were applied to each rooster. Roosters previously treated with nicotine sulphate were not treated.

Periodic examinations at approximately weekly intervals indicated that all roosters originally treated with a single nicotine sulphate treatment on January 22 were still free of mites March 21, while a few mites were present on roosters receiving 2 treatments of the other materials. By April 11, when observations on this series of treatments were discontinued, a few mites appeared on roosters treated with nicotine sulphate, while some of the roosters receiving other treatments were badly infested.

On April 11, 12 of the roosters from the above experiment, which had mite populations of 2 or greater, were used in a second experiment (Table 2). Four roosters were each treated with 2 drops of 40 per cent nicotine sulphate, 4 with 8 pinches of 5 per cent benzene hexachloride (.5 per cent gamma

Table 2.—A comparison of the northern fowl mite populations on roosters following treatment April 11, 1947 with 40 per cent nicotine sulphate, benzene hexachloride and 10 per cent sabadilla. Infestation rated on a scale of 1 to 10.

Date	Nicotine Sulphate Rooster No.				Benzene Hexachloride Rooster No.				Sabadilla Rooster No.			
	F	J	N	P	B	E	G	M	H	I	K	O
April 19	0	0	0	0	0	1	0	0	0	0	0	0
April 25	0	0	0	0	0	2	0	0	0	0	1	2
May 2	0	0	0	0	1	2	0	1	1	1	2	2
May 9	0	0	0	0	4	9	1	5	1	3	[1]	3

[1] Rooster died May 8 from head infection.

isomer content) dust, and 4 with 10 per cent sabadilla powder. Again, as in the first series of tests, only birds treated with nicotine sulphate remained free of mites for any considerable length of time.

At the same time that tests were being made with various materials on roosters in an egg-laying battery, observations were made on other heavily infested roosters which had been treated with 40 per cent nicotine sulphate (drop method). The first group of these roosters consisted of 10 males which were treated January 17, following which one male was put with each of 10 flocks of untreated hens in a Shenandoah laying house. These males remained free of mites for over 10 weeks, after which time a few mites were found on one of the 10 roosters. The second group of roosters consisted of a class pen of 11 cull males. Each of these birds was treated with 2 drops of 40 per cent nicotine sulphate March 7, 1947. At the time of the last examination on April 26 no mites could be found on any of the birds.

SUMMARY.—Laboratory studies and field tests indicate that 40 per cent nicotine sulfate, applied to roosters by the drop method is a very effective material for controlling the northern fowl mite. Other materials such as sodium fluoride powder, 10 per cent *Lethane* powder, 5 per cent DDT powder, 10 per cent sabadilla powder, and benzene hexachloride powder gave some initial relief but were only temporarily effective.—10-20-47.

Damage to Coffee by the Drug Store Beetle

E. R. DE ONG

Losses to coffee during storage or transit from the attacks of the drug store beetle, *Stegobium paniceum* (L.), are apparently not common as this insect, although listed as a cosmopolitan feeder, is seldom mentioned as a feeder on coffee. Recently, however, the author's attention was called to a severe insect infestation present throughout a shipment of several hundred bags of green coffee arriving in San Francisco from Colombia, S. A. The infesting insect proved to be the drug store beetle, the first and only serious infestation of coffee reported to the author, as consultant to the local marine shipping, over a period of many years.

Actual damage consisted of rounded burrows in the coffee bean made by the developing larvae and also small depressions eaten out of the bean by the adult beetle. Total damage consisted both of feeding and the presence of frass scattered through the coffee, thus requiring an expensive cleaning job. About 36 per cent of the shipment was infested and showed feeding damage but this was distributed throughout the entire shipment, not a single bag being found free from some degree of injury.

Responsibility for the origin of the infestation was definitely shown to be prior to loading, as the commonly accepted length of life history for this beetle is from three to five times longer than the time in

transit. It would thus be impossible for the infestation to have originated on the ship or to be so uniformly distributed if it had been. The feeding burrows in the coffee bean, of the developing larvae, proved that at least one generation of beetles had emerged and this could not be accidental contamination in transit.

The case history of this infestation leads to the assumption that the war period and the interrupted traffic following have led to a build up in numbers of the drug store beetle in South American warehouses and plantations which will probably continue to show up until transportation and warehouse sanitation is normal.—10-18-47.

Rearing House-flies on Common Bacteriological Media[1]

JOHN B. GERBERICH,[2] *University of Minnesota, Duluth Branch*

Research involving the necessity of rearing house-fly larvae in habitats with specific bacteria has stimulated this study of determining which of the more common bacteriological media can be used for the rearing of house-flies.

The method of using agar as a base with different dietary variations is not new and has been used by several investigators. Bacot (1911) used broth and agar media in his studies on the relationship of the house-fly and *Bacillus pyocyaneus;* Schannon (1922, 1923) reared Tabanids at first on beef extract agar but later obtained better results with beef infusions; and Wollman (1922) used gelose as a medium for rearing house-flies in a typhoid bacillus culture. Even though the technique is not new, very little information can be found as to what commercial bacterial media can successfully rear house-fly larvae. With our increasing knowledge of the possibilities of the house-fly acting as a vector of bacterial diseases more definite information seems pertinent as to what common media can be utilized by investigators in their studies of insect microbiology. This method is not useful for rearing house-flies on a large scale but it can be employed in establishing a common habitat for the development and growth of both organisms.

Thirty-five of the more commonly used commercial bacterial media were prepared as directed by the Difco Manual (1944) and sterilized under the same procedures as for bacteriological studies. The media were poured into sterile petri-dishes and allowed to stand for 6 hours. Between 10 and 20 fly eggs were placed upon a medium in a petri-dish. Evidence was produced that 15 cc. of medium would support about 10 maggots and when more than 10 were present in a petri-dish, cannibalism often occurred.

At the time the fly eggs are introduced into the dishes, the surplus moisture which forms from condensation upon the lid of the petri-dish was removed by a clean cloth. If the cultures are kept in a more or less constant temperature, the lid of the dish need not be dried more than once. It was found that the larvae are attracted to the water droplets, and the majority of them remain in the droplets either to dry up with the evaporation of the water or to die from starvation.

A second factor encountered which may cause difficulty is that the halves of the petri-dishes have a tendency to fuse together with a seal of water and shut off circulation of air. This can be avoided by raising the lids of the dishes daily. This will prevent the two pieces of glass from adhering together for any great length of time and will furnish sufficient air for the organisms.

Aseptic conditions were not maintained in this study because it was discovered that the maggots did not develop or grow on sterile media. If such conditions were desired to prevent contamination of a culture, it could be maintained by rapidly washing the house-fly eggs in a mixture consisting of half absolute alcohol and half 1 to 1000 corrosive sublimate solution and following the fundamental bacteriological practices of rearing pure cultures.

Thirty-five media (Table 1) were prepared and treated as previously mentioned. Eggs were placed on the top surface of each medium. Each plate contained about 15 cc. of medium. Two plates were prepared for each medium. All experiments were done at room temperature which was between 70 and 74° F.

Table 1.—Thirty-five media studied as artificial habitats for rearing house-flies. Roman numerals at the right of certain media indicate those satisfactory and the order of their productivity.

1. Beef Infusion Agar	XII
2. Beef Lactose Agar	I
3. Brain Heart Infusion Agar P.A.B.	III
4. Brain Heart Infusion	
5. Brain Heart Infusion P.A.B.	
6. Brain Liver Heart Agar	
7. Brain Veal Agar	VI
8. Dextrose Agar	VIII
9. Dextrose Broth	
10. Dextrose Starch Agar	
11. Entamoeba Agar	XI
12. Heart Infusion Agar	V
13. Heart Infusion Broth	
14. Koache Blood Culture	
15. Infusion Agar	
16. Lactose Agar	IX
17. Lactose Broth	
18. Loeffers Blood Serum	
19. Malt Agar	
20. North's Gelatin	
21. Nutrient Agar	
22. Nutrient Broth	
23. Nutrient Gelatin	
24. Nutritive Caseinate Agar	IV
25. Potato Dextrose Agar	
26. Potato Infusion Agar	XIV
27. Potato Infusion Broth	
28. Proteose Tryptone Agar	II
29. Stock Agar	
30. Tomato Infusion	XV
31. Tryptose Agar	XVI
32. Trypsin Digested Agar	VII
33. Tryptone Glucose Extract	X
34. Veal Infusion	
35. Veal Liver Agar	XIII

Of the 35 media studied, only 16 demonstrated possibilities of being usable; and of the 16, the first 10 mentioned in successive order of roman numerals (Table 1) were dependable. The digestive enzymes of the feeding maggots liquefied the gelatins, making both gelatins and broths unsatisfactory unless these types of media were absorbed in some mechanical agent such as paper. In the liquid states of both the above types of media the larvae would drown. The sixteen usable media all had an agar base and were rich in simple carbohydrates and proteins.

The eggs generally hatched within 24 to 36 hours after coming in contact with the media. The larvae

[1] Contribution No. 3 of the Department of Biology.

[2] Author wishes to thank Dr. C. E. Venard and the Dept. of Zoology and Entomology of The Ohio State University for their criticisms and materials in making this study possible.

feed by probing through the media, and by the end of the larval period the remaining medium was torn to small pieces and dehydrated. The larvae pupated in approximately 10 to 15 days, depending upon the medium used and the temperature. The flies emerged several days after pupation. The life cycle is about 10 days longer when using bacteriological media than the time required with the more common rearing medium of bran and alfalfa.

In order to complete the life cycle of the house-fly on artificial media a stimulant was necessary for deposition. Richardson & Richardson (1922) induced deposition on bran which volatilizes the products of decomposition of ammonium carbonate. Crumb & Lyon (1917) had success with carbonic and acetic acids. Through the efforts of trial and error of different concentrations of ammonium carbonate and glacial acetic acid, the most successful deposition was obtained with three drops of two per cent acetic acid in a 500 cc. flask.

The life cycle of the house-fly was completed upon bacteriological media by preparing the bottom of a 500 cc. filter flask with 2 inches of medium (beef lactose agar). The openings of the flasks were plugged with cotton. The flask was tilted as soon as the medium jelled to prevent the accumulation of moisture on the surface. After 24 hours the flask was drained of any surplus water and inoculated with adult flies which had been reared in the petri-dishes. Three drops of 2 per cent glacial acetic acid were placed upon a small piece of cotton and dropped to the center of the medium. The cotton prevents the acid from running over the surface of the agar. Acetic acid, if it comes in direct contact with the eggs, will injure them; but the gaseous products from the acid do not produce any injurious effects for the short period which the eggs are forced to endure. The cotton plugs should be removed as soon as deposition occurs and the air changed within the flask. Twenty-four hours after the flies were transferred deposition occurred providing the adult flies were at least 4 or 5 days old. The adult flies survived the stimulation but became "dopey" from the effects of the acetic acid. The adult flies were transferred to a rearing cage for future study and the eggs were transferred to agar plates where they hatched within 24 hours. There seemed to be no injurious effects of the stimulation either upon the larvae or the adult flies.—12-13-47.

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TWENTY-SECOND ANNUAL WESTERN COOPERATIVE SPRAY CONFERENCE

The Twenty-second Annual Conference of the Western Cooperative Spray Project was held at Portland, Oregon, on January 21 to 23 to discuss research work on the spraying problems in the deciduous orchards of the West.

Much interest was shown in the performance of parathion as well as of the other recently developed organic insecticides. There was more discussion than usual on the control of fungous diseases and on new types of machinery for applying sprays. Research work on orchard mites, pear thrips, cherry fruit fly, pear psylla, scale insects, aphids, cranberry and peach insects, and the codling moth was covered. Discussion of the last-named insect occupied much less time than usual owing to the generally satisfactory results being obtained with DDT.

Suggestions for the use of orchard sprays were revised and included a precautionary statement about parathion. These suggestions are often used as a basis for the recommendations issued by experiment stations and others.

A luncheon was held at noon on the last day with representatives of insecticide manufacturers and distributors, field men of growers' organizations, horticultural inspectors and county agents. A joint meeting followed, presided over by Ed Littooy, of the Colloidal Products Corporation, at which the suggestions covering the use of spray materials were discussed. Information was given on the availability of parathion and on possible limitations in its use, as well as on benzene hexachloride and on timely insect pest and spray machinery problems. The attendance at this meeting was about 250.

The closed sessions were larger than ever before, being attended by the following number of representatives of the member agencies: British Columbia Department of Agriculture, 3; Canadian Department of Agriculture, 5; Experiment Stations of California, 5; Colorado, 1; Idaho, 2; Montana, 1; Oregon, 11; Utah, 1; Washington, 16; and U. S. Department of Agriculture, 9. These included chemists, entomologists, horticulturists and plant pathologists. There were also about 20 accredited visitors, most of them from the State Departments of Agriculture of California, Oregon and Washington.

E. J. NEWCOMER, Yakima, Wash., *Chairman*
F. L. OVERLEY, Wenatchee, Wash., *Secretary*

JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

Vol. 41 February, 1948 No. 1

Entangling Alliances

Proposals have been made, from time to time, for the creation of new organizations in the general field of the biological sciences. And there exist, already, organizations of organizations in this field as well as in the broad general field of science.

The general objectives of such proposed and existing organizations have been to further the general interest of the participating groups. So far as can be learned by superficial consideration of existing plans this is to be accomplished largely through publicity; the sale of the work of the groups to the public in such fashion as to increase public support to their programs in the form of additional financial backing. And also, the idea of increased prestige of the members of the professions, as a result of the publicity is at least suggested in the arguments in favor of the organizations.

Entomologists have not, for reasons which will be suggested, been the moving spirits in the organization campaigns but have, at times, participated in the discussions, usually after plans have been so far outlined as to provide that leadership and control will be in the hands of other groups.

It has been made convincingly clear that new organizations will need the participation of the entomologists, and especially their financial support. It has not been made so clear what the benefits, if any, will be to the entomological groups. And it has not been demonstrated what the new organizations will do that could not, and should not, be done by existing organizations.

Entomologists are affiliated with the American Association for the Advancement of Science but have had, first and last, little hand in the direction of the policies of the Association. It is suggested that the entomological organizations benefit little from the affiliation; that entomologists as individuals probably should belong to the Association for the benefits which they, as individuals, receive, but that the entomological organizations might function just as well independently as they do in the Association. It could be that entomologists, as individuals, might profit by membership in other well-organized organizations of scientific men and might, in turn, through their individual cooperation, be of further service to the cause of science than they can be merely as members of the entomological organizations.

But additional organizations of organizations should be challenged to show a well-considered constructive program; to show why the participation of entomological organizations rather than independent entomologists, is desirable; to show that entomological organizations would be on a par with all other participating organizations and above all, to show that the super-organization is not just a step in the direction of regimentation and propaganda.

Members of the two entomological organizations have perfect cooperation; there is neither friction nor jealousy. And the Entomological organizations enjoy the most cordial relations with others in contiguous or overlapping fields such as Plant Pathology, Genetics and Plant Breeding, Chemistry and others. When their work overlaps they cooperate; when it does not, they go their own ways and pay their own way.

Super-organizations may be the coming thing; their arguments may be sound and their intentions altruistic and practical. Or, they may turn out to be wheels-within-wheels; obstacles to progress rather than instruments of progress.

Members of the entomological organizations may well consider whether they, whose organizational needs seem to be well filled as it is, wish to pay extra dollars

each year to additional groups just for the privilege of retaining membership in their own organizations. They may consider also whether they want their advertising to come from propaganda or from entomological achievements which will advertise themselves. While we must admit that it is the result of a very unusual combination of circumstances, it is true that entomology has never been better advertised, its importance has never been more widely realized and its support has never been better, than at the present time.

From the purely practical standpoint, affiliation with the proposed new organization means just this. A charge of one dollar per member of each affiliating organization is made. For perhaps a majority of our members that means two dollars each as they belong to both entomological groups now. It is impossible for either of the entomological groups to appropriate that sum from the present income. It would be necessary to make a special assessment for the purpose or to increase the dues, in each group, one dollar per member and then, in the case of the Association, pay over to the new group a sum in excess of $2,000.00 per year. (Nearer $3,500.00 if both organizations affiliate.)

A matter of this importance should never be decided in the business meeting at any annual meeting. It should be submitted to all the members in one of the letter ballots sent out from time to time, and a clear and decisive vote of the membership secured so that there should be no doubt as to the wish of the Association. A similar procedure would be in order for the Society.

It may be that time will demonstrate the need for new organizations in which entomologists will wish to participate, not because they are urged to do so, but because opportunity for additional service will be so obvious that it can not be denied or ignored. In the meantime, we may do well to maintain the policy of "Friendship with all—but entangling alliances with none."

FOURTH INTERNATIONAL CONGRESSES OF TROPICAL MEDICINE AND MALARIA

The Fourth International Congresses of Tropical Medicine and Malaria will be held in Washington, D. C., May 10–18, 1948. Work is under way by the organizing committee on the program including sectional meetings, exhibits, special features, and hospitality services. The congresses will be made up of the following sections:

I Research and Teaching Institutes
II Tropical Climatology and Physiology
III Bacterial and Spirochetal disease
IV Virus and Rickettsial diseases
V Malaria
VI Helminthic diseases
VII Protozoan diseases
VIII Nutritional diseases of the tropics
IX Tropical dermatology and mycology
X Tropical Veterinary Medicine
XI Public Health
XII Medical and Veterinary Entomology

F. C. Bishopp, representing the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, is a member of the Executive and Organizing Committees and has been appointed convener for Section XII Medical and Veterinary Entomology. W. D. Reed is a member of the organizing committee representing the American Association of Economic Entomologists and C. F. W. Muesebeck is representing the Entomological Society of America in a similar capacity.

PROCEEDINGS OF THE FIFTY-NINTH ANNUAL MEETING

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Congress Hotel, Chicago, Illinois, December 27, 28, 29 and 30, 1947

PRELIMINARY BUSINESS MEETING

A preliminary business session was held Sunday morning, December 28, when several of the standing committee reports were presented and adopted, and these full reports will be found elsewhere in the proceedings. The Resolutions Committee composed of G. M. Bentley, Chairman, Martin Muma, H. N. Worthley and F. W. Poos was announced by President Cory.

The proposed amendment to Article VI, Section 1 of the By-Laws to eliminate the "one month notice in writing" clause was adopted by the Association with three dissenting votes. The adoption of amendments to the By-Laws requires a two-thirds vote by the members present.

Since the "one month notice in writing" clause was eliminated from the By-Laws by action of the Association, a proposal to revise Article II, Section 6 of the By-Laws was presented by B. A. Porter. The revised version, with a change suggested by F. C. Bishopp specifying a tallying committee of three members was adopted by the Association, with three votes against the amendment. Various aspects of the amendment were discussed by S. A. Rohwer, J. L. Horsfall, F. C. Bishopp, W. C. O'Kane, R. C. Smith, Clay Lyle and Roy Campbell.

The following amendment to Article III, Section 2 of the Constitution presented at the Richmond meeting, December 9–12, 1946 was given final approval without any dissenting votes: "Article III, Section 2 shall be amended to read as follows: All Persons engaged in work in entomology or allied fields and other persons having suitable training or a deep interest in entomology may become active members upon consideration by and unanimous approval of the Membership Committee, after a regularly executed application, endorsed by two active members and accompanied by the required fee, has been filed with the Secretary-Treasurer."

There was considerable discussion of the report of the Committee on Common Names of Insects. During the spring of 1948, 56 common names for species of insects will be presented to the members for their action. The committee requested authority for its members to select common names for groups of insects higher than the category of species. This authority was granted by the Association with three dissenting votes. A proposal was approved to increase the committee to nine members and require a vote of seven members to adopt a common name.

The Committee on Popular Entomological Education attached a manuscript titled "A Manual for Guidance and Orientation for Entomology Students" prepared by Roger C. Smith to its report and recommended that the manual be referred to the Executive Committee for consideration and possible publication as a supplement to the JOURNAL OF ECONOMIC ENTOMOLOGY.

The fifty-ninth annual meeting of this Association was held at the Congress Hotel, Chicago, Illinois, December 27 to 30 jointly with the Entomological Society of America. Considering the crowded conditions in Chicago due to the annual meetings of the American Association for the Advancement of Science, and the unprecedentedly large registration of entomologists, about 500, the Association was fairly comfortably accommodated. A large measure of credit for the success of the meeting is due Dr. George C. Decker and his Local Committee on Arrangements.

The highlights of the program were as follows: Presidential Address "Totalitarian Insects" by President Ernest N. Cory; two symposia "Toxicology of Insecticides to Plants and Animals Other than Man," F. C. Bishopp, Leader and "Effects of Insecticides on Biological Control," Leader C. P. Clausen; and the Entomologists Banquet with Robert L. Patton as the banquet speaker whose subject was "Role of Radioactive Elements in Entomology."

REPORT OF THE SECRETARY TREASURER

It is rather difficult to pick out the more important matters that have transpired during the year that concern the welfare of the Association. From a personal point of view, the greatest concern is the amount of time that was devoted to its business affairs. The time required to do a reasonably acceptable job far exceeded my estimate, and I doubt that even a minimum standard was attained. Perhaps the members will be generous and attribute the difficulties to inexperience.

The Association's business increases yearly. The 1947 membership was 1983, 167 of whom were were elected at the Richmond meeting and the prospects are that the membership will increase about 200 during 1948. During 1947 there were 22 resignations, 12 deaths, including three past presidents, and 34 were dropped for non-payment of dues and subscriptions.

The JOURNAL'S affairs received considerable attention during the year, particularly printing costs and circulation. During 1946, the number of copies of the different issues printed varied somewhat, but some issues are already exhausted indicating that insufficient copies of some issues were printed. An analysis of the situation was made to determine how many copies should be ordered per issue. This study indicated a need for 3600 copies based on the mailing file. On October 1, there were about 140 copies each of the February, April, and June 1947 numbers on the inventory. Whether an inventory of this number of copies will prove adequate remains to be seen. Should any appreciable number of future members purchase back numbers, it may be insufficient. The foreign non-member subscriptions are increasing rapidly indicating the importance of the JOURNAL to foreign agriculture.

Printing costs of the JOURNAL have increased 48 per cent since June, 1946. The last increase was

about 18 per cent, effective with the October 1947 issue.

To facilitate some of the Business Office procedures, the Executive Committee authorized the purchase of a manually operated addressograph with certain attachments and embossed stencils of the Association mailing list. The cost of the outfit and the filing cabinets will be somewhat more than $500.00. The greatest benefit from this equipment should result in maintaining a more accurate JOURNAL mailing list. At present, supposedly duplicate mailing files are maintained at Menasha, Wisconsin, and College Park, Maryland; but it seems to be an impossible task to keep them in accord. The present discrepancy between the two lists represents an appreciable loss to the JOURNAL account. When this equipment becomes available early in 1948, the Menasha file will be discontinued and one file maintained, entirely under the control of the Business Office at College Park.

Handling of the new method of electing the President and First Vice President proved to be quite a task, primarily because Article III, Section 2 of the By-Laws, as amended, did not provide for procedure. The necessary procedures were approved by the Executive Committee step by step until a President and First Vice President were finally elected. Despite all the difficulties encountered, the principles contained in the amendment appear to be sound, and, with a few minor changes, the amendment can be made workable and retain all of its democratic principles. The long list of nominees on the first ballot has drawn considerable criticism, but members wrote in many names of their own choice throughout the balloting. This latter condition possibly indicates the desire of the membership as a whole, for a wide choice of names from which to choose. Serious consideration should be given to correcting the weaknesses of the present By-Law as amended before embarking on a new and untried scheme.

The Special Nominating Committee provided in the Amended By-Laws was composed of:

B. A. PORTER, First Vice President
H. S. MCCONNELL, Secretary
E. O. ESSIG, Past President—1944
D. L. VAN DINE, Past President—1945
CLAY LYLE, Past President—1946
S. A. ROHWER, Past First Vice President—1944
———Past First Vice President—1945 deceased
H. G. CRAWFORD, Past First Vice President—1946
W. J. O'NEILL, Chmn. Pacific Slope Branch
J. O. PEPPER, Chmn. Eastern Branch
DWIGHT ISELY, Chmn. Cotton States Branch
H. M. HARRIS, Chmn. North Central States Branch

The Secretary wishes to express his appreciation to those members who contributed their time to tabulate the votes cast on the three ballots, as follows; first ballot—Engel Gilbert, Ashley B. Gurney and Floyd F. Smith; second ballot—T. L. Bissell, Engel Gilbert and Floyd F. Smith; third ballot—E. R. McGovran, F. W. Poos and Floyd F. Smith.

Progress continues on the preparation of Volume VII of the Index. Dr. Bromley, the Editor, has the photo-printed cards in his possession. However, it is impossible at this time to predict the date when this Volume will be available for distribution. The publisher of the JOURNAL OF ECONOMIC ENTOMOLOGY who published some of the previous Indices has indicated that the samples of photo-printed cards are difficult to work from, and would require an excessive amount of time for type-setting. Since this company is operating at maximum capacity and barely able to meet its schedules, it is unable to indicate a foreseeable date when a bid could be submitted. Dr. Bromley reports that one other printing establishment has indicated some interest in doing the job.

REPORT OF THE EXECUTIVE COMMITTEE

There were no meetings of the Executive Committee during 1947 until the annual meeting at Chicago. However, a number of important matters were considered by correspondence previous to the arrival of the eight members of the Committee in Chicago.

There was a great deal of correspondence pertaining to the new method of electing the two Association officers by mail ballot. It was early evident that some action by the Committee was necessary before even a beginning could be made by the Secretary to conduct the election. In an effort to conform as closely to the wording of this amendment as possible, three directives were approved in May which it was thought would cover the situation, but these proved to be inadequate. Several other directives were necessary before a President and First Vice President were finally selected.

Other matters considered by correspondence during the year were as follows:

1. Approval of the purchase of an addressing machine for the office of the Secretary-Treasurer.

2. Disapproval of a proposal by the American Association for the Advancement of Science that all affiliated societies charge a registration fee to aid in defraying the expenses of the AAAS meetings in Chicago.

3. Approved the remission of dues of Dr. H. T. Fernald and that he be continued as an active member.

Several sessions of the Executive Committee were held during the Chicago meetings. The committee voted to support the proposed amendment to Article VI, Section 1 which would eliminate the "one month notice in writing" clause when it was agreed that the Association would have the opportunity to restore the amendment at the final business session. In connection with the above amendment, which was proposed to make it possible to clarify the mail ballot method of electing the President and First Vice President, at the Chicago meeting, the committee voted to recommend that the Amendment of Article II, Section 6 of the By-Laws as approved at the Richmond meeting be changed to read as follows: (see appended pages)

The Committee approved the destruction of ballots pertaining to the election of President and First Vice President, and directed that the signed tally sheets should be retained as permanent records.

Due to increased costs of printing the committee approved an increase of paid articles in the JOURNAL from $6.00 per page to $10.00 per page.

The Committee also approved the reprinting of certain issues of the JOURNAL which had been purchased by the American Library Association and were not delivered before the regularly printed issues were exhausted.

A list of items recommended by the Committee and approved by the Association will be found listed in the discussion of the Final Business Session.

SUGGESTED REVISION OF ARTICLE II, SECTION 6 OF THE BY-LAWS

Section 6. All officers and standing committees, except the President and First Vice President, who shall be nominated and elected as hereinafter provided, shall be elected by ballot after recommendations have been made by a nominating committee, provided that nominations of equal validity may be made from the floor.

At least four months prior to each annual meeting the Secretary shall invite each member of a special nominating committee consisting of the First Vice-President, the Secretary, the three immediately preceding past Presidents, the three immediately preceding First Vice Presidents and the Chairman of each of the Branches, to propose one name for President and one name for First Vice-President. All of these names, arranged alphabetically for each office, shall be placed on a ballot to be submitted to the membership. Any candidate named for both offices shall be included only in the list of candidates for the position of President. A ballot shall be mailed to each member not later than three months before the annual meeting, with the request that he indicate his preference on the ballot and return it in a special envelope marked "Ballot." A definite deadline for the return of the ballots, not less than thirty days from the date when they are mailed out, shall be specified, and no ballots received later than the specified deadline shall be counted. Members may write in other names of their choice. The votes shall be tabulated by a special committee of three members selected by the Secretary.

If for either position no candidate receives a majority of all votes cast, the three candidates for such office receiving the greatest number of votes, or in case of a third-place tie, the four receiving the highest number of votes shall be placed on a run-off ballot, which shall be mailed to the membership, with a time limit of not less than thirty days from the date of mailing for their return, as with the first ballot. The ballots shall be counted as before. On the run-off ballot the candidate for each office who receives the greatest number of votes shall be declared elected. The regular nominating committee and the candidates for each office shall be immediately notified of the outcome.

FINAL BUSINESS SESSION

Several reports that were not presented at the Preliminary Business session were heard at this session.

A petition with required number of signatures, approved by the Executive Committee for the formation of a Section of Medical Entomology was approved by the Association.

The Executive Committee recommended and the Association approved the following items:

1. That the American Association of Economic Entomologists not take affirmative action at this time on the invitation to become a member of the American Institute of Biological Sciences.

2. That the 1948 annual meeting of the Association be held in New York City, December 13 or 14, 1948.

3. That Dr. J. C. Bradley and Dr. Robert L. Usinger be appointed delegates to the International Congress of Entomology which will meet in Stockholm, Sweden in 1948 and that the Association reimburse them for their registration fees.

4. That W. B. Herms, Robert Matheson, the outgoing President and the incoming President be designated official delegates of the Association to the International Congresses of Tropical Medicine and Malaria which will meet in Washington, D. C., May 10 to 18, 1948, and that the Association bear the expense of their registration fees.

5. That as a token of recognition of long and distinguished service in the American Association of Economic Entomologists, the dues of Mabel Colcord, Herbert Osborn and W.A. Riley be remitted and that they be continued as active members.

The Executive Committee recommended that the annual dues of the Association be increased from $2.00 to $3.00 beginning in 1949 and the Editorial Board of the JOURNAL OF ECONOMIC ENTOMOLOGY recommended that the Association approve the increase of membership subscription to the JOURNAL from $3.00 to $3.50. The Interim Secretary read these two recommendations and commented that they involved the revision of two different articles of the By-Laws and recommended their adoption which was seconded from the floor. An involved discussion ensued concerning the above recommendation with one to make the total of annual dues and membership subscription $7.00 and one to give special consideration to entomology students and graduate students. The motion to give students special consideration was defeated. A difference of opinion exists among members whether the Association voted to approve a total of $7.00 for dues and subscription, or the two combined recommendations first presented, by the Executive Committee and the JOURNAL Editorial Board. It is the Interim Secretary's opinion that the $7.00 dues and subscription motion was not properly made despite the fact that it included a statement that the Executive Committee should apportion the $7.00 between the annual dues and subscription. At least that part pertaining to membership subscription should have been referred to the Editorial Board of the JOURNAL for approval before it could be considered a substitute or an amendment to the motion that was first presented and properly seconded.

On a motion made from the floor, the Association approved the increase of non-member subscriptions to the JOURNAL from $5.00 to $6.00.

A motion was made and adopted that Article VI Section 1 as amended at the Preliminary Business Meeting be further amended to restore the "one month notice in writing" clause, so that Article VI, Section 1 of the By-Laws shall read as follows:

"Changes in these by-laws may be made by a two-thirds vote of the members present at any meeting: Provided that notice in writing of the proposed amendment shall have been sent to every active member at least one month before the date of the meeting at which it will be considered."

The presidency of this Association should be bestowed as a reward for sustained effort in behalf of the Association and in the belief that the individual selected will continue to function successfully. This was the basis of the old nomination procedure and it is a source of great satisfaction to me personally that this basis has been followed in the new procedure. I know of no member judged by the criteria mentioned, who more richly deserved the bestowal of this honor.

ERNEST N. CORY

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

GENERAL FUND

STATEMENT OF RECEIPTS AND DISBURSEMENTS FOR THE FISCAL YEAR ENDED NOVEMBER 30, 1947

	TOTAL	JOURNAL	ASSOCIATION	INDICES
Receipts:				
Subscriptions—current and future years	$10,887.74	$10,887.74		
Subscriptions—prior years	1,360.00	1,360.00		
Advertising	687.66	678.66		
Reprints	1,086.06	1,086.06		
Back numbers and miscellaneous	1,020.34	1,020.34		
Dues—1948 and future years	2,347.00		$1,760.25	$ 586.75
Dues—1947	1,647.10		1,235.33	411.77
Dues—1946	165.00		123.75	41.25
Dues—1945	26.00		19.50	6.50
Sale of indices	119.50			119.50
Interest on bonds	50.00		50.00	
Withheld from employee for Old Age Benefit tax (to be refunded)	7.50		7.50	
Federal income tax withheld from employee (net)	284.00		284.00	
Total receipts	$10,678.90	$15,032.80	$3,480.33	$1,165.77
Disbursements:				
Printing (including JOURNAL mailing costs)	$10,942.52	$10,942.62		
Engravings	393.79	393.79		
Salaries and wages—stenographic and clerical	3,359.54	1,679.77	$1,679.77	
Traveling expenses	887.18		887.18	
Reimbursement to Cotton States Branch for expenses	117.93		117.93	
Postage, stationery, and office supplies	523.99	261.99	262.00	
Telephone and telegraph	76.53		76.53	
Accounting service	50.00	25.00	25.00	
Insurance	39.72	19.86	19.86	
Express	15.92		15.92	
Bank service charges	31.38	15.69	15.69	
Safe deposit box rental	7.20		7.20	
Meetings expense	133.24		133.24	
Office equipment	80.00		80.00	
Cash shortage arising at December 1946 meeting, Richmond	5.00		5.00	
Total disbursements	$16,664.04	$13,338.72	$3,325.32	—
Excess of receipts over disbursements	$ 3,014.86	$ 1,694.08	$ 155.01	$1,165.77
Add: Balance November 30, 1946, per previous report	6,739.18	518.17*	6,146.72	1,170.63
Balance, November 30, 1947	$ 9,754.04	$ 1,115.91	$6,301.73	$2,336.40
Balance consists of:				
Cash in Prince Georges Bank & Trust Co. (checking account)	$ 7,754.04			
U. S. Savings Bonds, Series G, 2½%, (at cost)	2,000.00			
	$ 9,754.04			

* Indicates deficit.

PERMANENT FUND

Balance, November 30, 1946		$26,025.14
Receipts:		
Interest on bonds	$ 423.75	
Interest on savings deposit	32.62	
Increment to redemption value of U. S. Savings Bonds, Series D, (added to book value)	400.00	
Life memberships	200.00	
		1,056.37
Disbursements:		
None		
Balance, November 30, 1947		$27,081.51
Balance consists of:		
Securities		
FACE AMOUNT	BOOK VALUE	
$ 2,000 Province of Ontario 5% Debenture Bonds due May 1, 1959, at cost	$2,000.00	
3,000 U. S. Treasury 2½% Bonds of 1955–1960, at cost	2,984.00	
10,000 U. S. Savings Bonds, Series D, due Feb. 1, 1949, at current redemption value	9,400.00	
7,000 U. S. Savings Bonds, Series G, 2½%, at cost	7,000.00	
		$21,384.00
Cash in Prince Georges Bank & Trust Co. (savings account)		5,697.51
		$27,081.51

SPECIAL JOURNAL FUND

Balance, November 30, 1946	$507.50
Receipts:	
Interest on savings deposit	5.05
Disbursements:	
None	
Balance, November 30, 1947, consisting of cash in Prince Georges Bank & Trust Co. (savings account)	$512.55

AUDITOR'S REPORT

December 24, 1947

Mr. H. S. McConnell, *Secretary-Treasurer*
American Association of Economic Entomologists
College Park, Maryland

Dear Mr. McConnell:

I have examined the accompanying statements of receipts and disbursements of the General Fund, Permanent Fund, and Special Journal Fund of the American Association of Economic Entomologists for the fiscal year ended November 30, 1947, have reviewed the accounting procedures of the Association, and without making a detailed audit of the transactions, have examined or tested the records of the Association and other supporting evidence by methods and to the extent deemed appropriate. My examination was made in accordance with generally accepted auditing standards applicable in the circumstances and included all procedures which I considered necessary.

In my opinion, the accompanying statements of receipts and disbursements of the General Fund, Permanent Fund and Special Journal Fund fairly present the recorded cash transactions of the Association during the fiscal period and its cash and securities position at November 30, 1947.

Yours very truly,
PAUL E. PYLES
Certified Public Accountant

REPORT OF THE RESOLUTIONS COMMITTEE

Your committee recommends the acceptance of the following resolutions:

1. WHEREAS, the 59th Annual Meeting of the American Association of Economic Entomologists has been most successfully conducted, be it resolved that the thanks of the Association be extended to the following individuals and agencies that have contributed to this end:
   a. The interim Secretary, H. S. McConnell, and the local committee on arrangements, George C. Decker, Chairman, C. Norman Dold, Charles Seevers, Edward L. Thomas, Rupert L. Wenzel for their capable handling of the innumerable organization details essential to the smooth functioning of the schedules sessions.
   b. The program committee, A. M. Boyce, Chairman, E. F. Knipling, C. E. Palm, for the excellent program provided.
   c. The officers and members of the Entomological Society of America for their wholehearted cooperation in the joint sessions.
   d. To the local press for its careful and conscientious reporting of the papers presented.
2. That the Secretary of the Association send greetings to our beloved charter members whose names figure so prominently in the history of the Association, Dr. Leland O. Howard and Dr. Hebert Osborn.
3. That the National Food Conservation program be heartily endorsed, that all members of the Association be urged to give it their active support, and that the work of the Bureau of Entomology and Plant Quarantine through Dr. R. T. Cotton and his staff in furthering this program be commended.
4. That the thanks of the Association are hereby extended to the members of the insecticide industry for their valuable cooperation in the task of developing and evaluating pest control chemicals.
5. That in view of evidence reported at this meeting of the many and varied possible effects of synthetic organic compounds upon plants, animals, and man, this Association urges that sufficiently careful consideration be given to such effects and that members use the utmost caution in the preparation of suggestions and recommendations.

M. H. MUMA H. N. WORTHLEY
F. W. POOS G. M. BENTLEY, *Chairman*

REPORT OF COMMITTEE ON COOPERATION WITH PEST CONTROL INDUSTRY

Largely as a result of great strides taken in the application of the findings of research in economic entomology to control the problems of household, industrial and structural pests, which were further stimulated by conditions engendered during the last war, the co-operation between professional entomologists and pest control operators has become increasingly close. It is hoped that this co-operation will increase in the future for the general welfare of the community.

There is no doubt that, in North America, the industry by organizing the National pest Control Association of the United States, and the Canadian Pest Control Operators' Association and a number of State, Provincial, and Regional organizations is serious in its attempts to improve the efficiency of its members, and to secure a good name for the industry as a whole.

LEGISLATION

At present there are seven states that have laws with jurisdiction over the activities of pest control operators. These laws vary in their approach to the problem of providing rules and regulations, and although some have been in effect for more than a decade, the value of this type of legislation is still not fully determined.

There is a rather general consensus of opinion that the most constructive approach to the problem of legislative regulation of pest control service is to regard the pest control operator as a member of a profession. There is a feeling that legislation should employ a minimum of specific rules and regulations, and should be more a matter of licensing of operators on a basis of experience, competence and evidence of responsibility.

If the leaders of both the National and Canadian organizations recognize and assume the responsibility of representing the pest control industry within and without the membership of their organizations, then they must also assume the task of providing standards of performance and public responsibility for the members of the industry.

If the national organizations fail to provide and enforce reasonable standards of performance and ethical conduct on the part of the membership of the industry, then there will be a possible necessity of regulatory legislation.

RESEARCH:

It has been a constant complaint in previous reports of this committee and also of entomologists

and pest control operators generally, that research on household, stored product, and structural pests generally is not conducted on a scale proportional to the importance of the problems involved. This may be largely due to the fact that research in economic entomology is usually sponsored from agricultural sources, and it is only natural that emphasis should usually be placed on essentially agricultural problems. This is an aspect of the application of research appropriations which should receive much closer attention than it has in the past.

TECHNICAL INFORMATION:

Entomologists in contact with the Pest Control Industry are continually called upon for technical information in the identification of insects and for methods of control. Entomologists have worked very closely with the pest control industry in this regard, and the tendency has been to encourage this. The experience has been that in this way new pests or problems can be brought to the attention of the authorities at an early stage. For instance, during the last year at least three important pests, not hitherto known to be of economic importance in parts of Canada, were brought to the attention of the Dominion Government Service, as a result of direct inquiries from operators who had been called in to deal with these pests, and who did not attempt control methods without an exact determination of the insects involved. This is certainly a good attitude on the part of the industry which works for the benefit not only of all concerned from the technical point of view, but for the general public as well. An instance is also reported of an operator in New York, in contact with competent authorities, who made the original discovery that a mouse mite carries an organism transmitting a new fever, Rickettsial Pox.

EXTENSION:

Entomologists are asked to attend meetings of the pest control associations and to give papers. In the course of the discussion following such presentations, the entomologists have an opportunity to understand the point of view of the practical operator, and new problems are constantly brought to their attention in this way.

More states and provinces are giving consideration to the organization of short courses, sponsored and supported by universities and colleges.

PRACTICAL CO-OPERATION ON PROJECTS:

As a result of co-operative projects initiated during the war, entomologists have continued to work closely with the Industry. An outstanding illustration of this is the work done during the last season on fumigation tests for the control of dry wood termites in California, by the Division of Forest Insect Investigations of the B.E.P.Q., U.S.D.A. and the pest control operators in that state.

SUPERVISION OF WORK:

An interesting field of co-operation has developed in Canada, similar to that experienced in the United States, as a result of the decision of the Dominion Government Department of Agriculture in 1942, to place in the hands of qualified members of the Canadian pest control industry, some phases of its campaign to control large insect populations found in imported plant products. This work was started during the war and proved so beneficial in the prevention of the spread of these populations to other products, that it was decided to continue it until further notice. Most of the work is carried out by fumigation of the products in railway box cars, lake and river boats, barges etc., as soon as possible after the arrival of the commodities in the country. The empty holds of the steamers bringing in the produce are also treated by spraying or fumigation. The work is done largely by the operators working under the supervision of entomologists and inspectors of the Dominion Department of Agriculture. In this way direct supervision and acceptance of the work of the industry lies in the hands of the Government Officials. This has led to the very satisfactory application of the control methods under a wide variety of conditions. At the same time, research work is carried on in the Government Laboratories, to aid in the carrying out of this program, and in this way an opportunity is afforded to see how the various schedules developed in the laboratory stand up under practical working conditions. As might be expected, the operators themselves are able to develop new equipment and techniques for this work which helps the investigators in their efforts to widen the scope of the treatments.

The great advance made in the co-operative attitude of the industry is demonstrated in this particular project, for it has been found that if one operator develops a new technique to overcome a certain difficulty, he proves willing for this development to be communicated, via his association or the supervising authorities, to his competitors engaged in the same type of work.

This latter aspect of the subject carries the whole question of co-operation a very long way, as under previous conditions there was a strong tendency on the part of individual operators to keep their methods as secret as possible.

F. W. FLETCHER G. L. HOCKENYOS
H. A. U. MONRO, *Chairman*

REPORT OF COMMITTEE ON POPULAR ENTOMOLOGICAL EDUCATION

The committee on Popular Entomological Education has given study to procedures for popularizing Entomology. There is probably no subject with more potentialities for creating public interest than insects. The lives of all people are affected either directly or indirectly by insects, yet the great masses of people have but little understanding of the unseen role insects play in their daily lives, or how they affect the economy of the nation. Valuable information pertaining to crop pests and their control is being released to the public, particularly through farm papers. This information considering its limited scope is very well handled. However, farm journal information for the most part is of a specialized nature adapted for specific needs and therefore does not "fire" the imagination of the great masses in the sense of popularizing the subject.

The committee recommends that this Association through its executive committee and the entomological profession establish facilities for organized popular entomological education. The science of Entomology has sufficient research background that the journalistic profession may be encouraged to develop more and better success stories of a popular nature, depicting what the science of Entomology is accomplishing for the welfare of the public.

The committee is agreed that if Entomology is to be popularized or effectively propagandized there must be some organized source from which information may flow. If this source is to function effectively

it must be authorized by responsible agencies and administered by qualified personnel.

Organized educational activities on entomological subjects should be fostered and encouraged among school children, 4-H Club members, F.F.A. Clubs, Boy Scouts, Girl Scouts and similar groups.

An organization to provide timely and interesting information and keep popular magazines and the journalistic profession in close contact with entomological activities is essential.

Last year's committee on Popular Entomological Education stated that the American Society of Agronomy had recommended that that Society publish a semipopular magazine to serve the large number of people between the scientist and the farmer, as well as farmers and farm managers having more than a popular interest in new developments. It is recommended that the entomologists give thought to a similar publication. Entomology is one of the few professions that does not have available a popular or trade magazine. It would be practical to arrange such a publication without detracting from or interfering with present publications, either scientific or commercial.

JOHN E. DAVIS WILLIAM E. BLAUVELT
Z. P. METCALF GLEN E. LEHKER
GEORGE S. LANGFORD, *Chairman*

REPORT OF COMMITTEE ON COMMON NAMES OF INSECTS

On December 15, 1947 the Committee had on hand 56 proposals for additions to the official list of common names, and also proposals for changes in 5 approved names. It is recommended that the distribution of another ballot in the spring of 1948 be authorized.

Further study has been given the subject of common names for families and other groups of insects. The development of this list, undertaken upon instructions to the Committee voted at the Dallas meeting, has progressed to the point where early submission to the membership is possible. The list can be prepared in ballot form by the spring of 1948 if it is decided to refer it to the whole membership of the Association. That course, however, does not seem to the committee to be practical. More than 400 names will be involved and it is not believed that a ballot with so many names will receive thorough consideration by the membership as a whole. It is, therefore, recommended that the Committee be authorized, after detailed study, and consultation with other members, to take final action on these names and to publish the list in the JOURNAL OF ECONOMIC ENTOMOLOGY as soon as practicable.

DON C. MOTE A. V. MITCHENER
H. M. HARRIS G. J. HAEUSSLER
F. W. POOS C. F. W. MUESEBECK, *Chairman*

REPORT OF THE COMMITTEE ON INSECTICIDE TERMINOLOGY

The Committee on Insecticide Terminology has been active, during the year, on four principal objectives: (1) To establish methods of handling proposed names of insecticides within the Committee; (2) consideration of suitable names for insecticides that are now known only by long, unwieldy chemical names or by trade-marked names; (3) consideration of names proposed by other committees or agencies; (4) rules for naming insecticides.

The method of handling the work within the Committee has been to circularize each member with a list of insecticides that appear to need popular names and with any names proposed by outside committees or agencies. Then either a vote, an opinion, or comment is solicited from each member. This has proved to be a time-consuming method, but in view of the newness and difficulties of the subject, the method is believed justified. Ways of speeding up Committee action should be considered in the near future. For the present, the Committee feels that 5 members represents an adequate size.

The following list of insecticides was submitted to the Committee for naming: DDT; Colorado 9; Toxaphene; B-butoxy-B^1-thiocyanodiethyl ether; B, B^1-dichloroethyl ether; piperonyl butoxide. The Committee rejected consideration of names for all but the last insecticide; that one is still under consideration. Some other insecticides have been considered informally for naming, but have not yet been taken up by the entire Committee.

The Federal Interdepartmental Committee on Pest Control, which is empowered to determine and establish suitable names of insecticides to be used in the ingredient statement on containers, has sent, during the year the following names for consideration of your Committee: benzene hexachloride for 1,2,3,4,5,6-hexachlorocyclohexane, chlordane for the complex chlorinated indan derivative, first known under the trade name Velsicol 1068, methoxychlor for the methoxy analog of DDT, and parathion for OO,-diethyl-O-p-nitrophenyl thiophosphate. Benzene hexachloride and parathion were approved without change by the Committee. Chlordane was changed in spelling to chlordan on recommendation of the Committee on Nomenclature of the American Chemical Society. This committee has establihsed rules of nomenclature which reserve the terminal "-ane" for certain types of compounds of a structure different from that of the indan derivatives. Your Committee voted to follow the ACS Committees' recommendation on this name. The spelling, chlordan, is at present in use in Chemical Abstracts and in Chemical and Engineering News, both publications of the American Chemical Society. Methoxychlor was rejected by your Committee because it is an incomplete word and not descriptive of the compound even though it violates no established rule of chemical nomenclature. It was approved by the Interdepartmental Committee on December 9 as a common name for the methoxy analog of DDT. No further action has been taken this year by your Committee on this name.

Regarding rules for naming, two suggestions have been received which delimit rather well the whole field: (1) to classify insecticides into broad groups, assigning class names to the groups, and attaching numbers to the class names that indicate the specific insecticides; (2) to select names by arbitrary choice of euphonious and unpreempted designations without special regard to the generic chemical relationships of the named materials.

Both systems of naming have advantages and disadvantages. A classified system like (1), if well designed, might be more acceptable to industry than (2) since all insecticides would be treated alike and naming would not be left to the vagaries of individual or small-group decision. On the other hand, arbitrarily chosen names are apt to be shorter, less technical, and therefore more acceptable to the general

public than names derived from a classified system. The difficulty seems to lie in the fact that good naming is an art that too few possess. Aside from the general agreement that insecticides should be designated by names, and that the names should be short, easily pronounced and spelled, not uncouth or barbaric, not easily nicknamed or hyphenated, and within the rules of chemical nomenclature, there is little to follow in selecting arbitrary names. The subject of rules for naming insecticides is now before your Committee for study; it is hoped that something more definite can be reported at a later date.

Your Committee has cooperated with the Federal Interdepartmental Committee on Pest Control, and the ACS Committee on Chemical Nomenclature, and with some industrial groups and individuals in the matter of naming insecticides. An increasing number of groups and individuals are becoming interested in the subject. Progress has been slow, but indications are that cooperation will increase in efficiency as the details of proposing and approving names are worked out and become more familiar.

GLEN CARMAN
J. R. EYER
R. C. ROARK
H. H. SHEPARD
C. H. RICHARDSON, *Chairman*

REPORT OF COMMITTEE ON GRASSHOPPER RESEARCH

At the Conference held by the Committee on Grasshopper Research in Lincoln, Nebraska, September 11 to 14, 1945, a series of general objectives were adopted to serve as a guide in the development of future grasshopper research programs.

On March 21 to 24, 1947, a second conference of the committee was held in St. Paul, Minnesota, which was attended by all members of the committee and by other entomologists interested in grasshopper research in Canada and the United States. The purpose of this meeting was to provide an opportunity for the members of the Committee on Grasshopper Research to decide how they as members of this committee could forward the objectives outlined in the previous conference held at Lincoln in 1945.

Dr. B. P. Uvarov, Director, Anti-Locust Research Center, London, England, was invited to attend this conference to aid the committee in formulating objectives which they as a committee could undertake, as well as aiding them in assigning priorities to various problems.

Following discussions by Dr. Uvarov and members of the Committee regarding the primary objective of grasshopper research, the following resolution was adopted: "That the object of grasshopper research should be the elimination of grasshoppers before they become an economic threat."

In general it was agreed that the recommendations contained in the three sub-committee reports adopted at the Lincoln Conference (JOUR. ECON. ENT. 39: No. 1, 1946) should continue to serve as a basis for setting up new projects and rearranging programs already in effect. However, the committee resolved that prior attention should be given the following urgent problems:

(1) The annual mapping for each species of primary and secondary grasshopper areas. This should be done from records already available and should be continued, to establish the existence or otherwise of endemic population centers.
(2) Projects having as their objective the development of methods for determining grasshopper populations.
(3) Studies in the field biology and behavior of the various economic species of grasshoppers having as their objectives the interpretation of various behavior patterns observed in the field.
(4) Studies on food plants and nutrition in relation to grasshopper reproductive capacity, development and survival.

It was the feeling of the committee that they as a body could not undertake to direct and coordinate such an extensive program as was adapted at the Lincoln conference. Among the various reasons brought forth were, that the members of the Committee were not in a position to spend the necessary time required to formulate and assign priority to the various problems. As a result of these discussions it was resolved that efforts be continued to locate a source of funds for the employment of a permanent or executive secretary for the Committee, as had been previously recommended at the Lincoln conference. To best carry out the program it was recommended that the duties of the secretary be as follows:

(1) To summarize, digest and chart past research findings.
(2) To prepare a summary chart of work in progress at present.
(3) To prepare insofar as possible, for approval of the Committee, a list of projects which, taken step by step, might be expected ultimately to help attain the objective defined in the first resolution of the Committee.
(4) To be prepared to suggest, via the Committee, projects to Experiment Stations, Graduate students, industrial concerns, etc., who may be interested in grasshopper research.
(5) To keep an up-to-date summary of results obtained, to serve as a continuous guide in aiding convergence on the common objective.

In closing it was resolved that the Committee urge upon administrators the necessity of providing funds for more prompt publication of grasshopper research findings. In addition, it was further resolved that the Committee request the privilege of receiving from the Anti-Locust Research Center, London, England, annual abstracts and digests of literature on locust and grasshopper research; and further, in order to ensure completeness of the above, all grasshopper research workers in the United States and Canada be urged to supply the Anti-Locust Research Center with three copies of any and all publications of grasshopper research results as soon as such appear.

Continuing the practice of former years, the Committee arranged for the assembling and distribution of a confidential report on grasshopper research conducted in Canada and the United States during 1946.

GEORGE C. DECKER
R. H. HANDFORD
C. E. MICKEL
J. R. PARKER
H. L. SEAMANS
CLAUDE WAKELAND
J. H. PEPPER, *Chairman*

REPORT OF COMMITTEE ON THE CODLING MOTH

In accordance with usual practice, the Committee has requested the Bureau of Entomology and Plant Quarantine to assemble available information on

the 1947 season's work with the codling moth, and distribute it as the usual pool of information. Invitations have gone to the codling moth workers to submit information on the past season's work, both on the codling moth and on associated problems such as orchard mite control.

The Committee sponsored an all-day conference at Des Moines, Iowa, on March 26, 1947. This was the first conference on the codling moth that had been held since January 1938. The conference was well attended and those present seemed to feel that it was worth while. No conference is being scheduled for this winter.

With the general adoption of DDT wherever worm control has been especially difficult, the problem has subsided to one of lesser importance. In fact, many workers now consider the codling moth a minor problem. There are, however, a number of things that your committee feels should be further investigated. Further development of the blower type of equipment, and the plane and helicopter, is needed in order that DDT and other materials may be applied in concentreated form. The use of such equipment would increase greatly the speed of application, and would eliminate the use of tremendous volumes of water, necessary with present conventional equipment. Accompanying the work with new equipment should be studies of formulations for use with it. A more complete study is needed in many areas of the number of applications of DDT and the best timing of such applications to control the codling moth. A further fundamental investigation of the inter-relationships between various orchard insect pests, their natural enemies, and the use of DDT is very much needed. Workers should also be very much on the alert to detect any indications that a resistance to DDT is being built up by the codling moth.

With the codling moth subsiding to a position of lesser, if not minor, importance, there is some question whether the Association's Committee on the Codling Moth is needed any more. Many of those who have been consulted in the matter have suggested that its scope be broadened to include consideration of related orchard problems, particularly those growing out of the use of DDT, such as mite control. This matter should be carefully considered by the Executive Committee and the Association.

A. D. BORDEN G. E. MARSHALL
DWIGHT ISELY P. J. CHAPMAN
W. J. O'NEILL B. A. PORTER, *Chairman*

REPORT OF THE COMMITTEE ON THE RELATION OF ENTOMOLOGY TO CONSERVATION

Last year's report of this committee called attention to the possible dangers in the widespread distribution of DDT and other insecticides. It was pointed out that many forms of life may be adversely affected along with the obnoxious insects. That report also pointed out the need for adequate study of this problem and commended the work under way between the Bureau of Entomology and Plant Quarantine and the Fish and Wildlife Service to determine some of these effects. The committee feels it is desirable this year to report briefly on the preliminary results from some of these studies centered at Beltsville, Maryland.

While the present report primarily concerns the the cooperative work between these two agencies, it should be mentioned that significant studies along similar lines have been conducted or are under way by other groups. Investigations of possible adverse effects of mosquito control operations have been intensively followed by the U. S. Public Health Service and the T. V. A. Results of this work already have been reported in part.

When it became evident early in 1945 that large forested areas would be treated by Federal and State agencies with DDT dispersed by airplanes, plans were laid by personnel of the Division of Forest Insect Investigations (Bureau of Entomology and Plant Quarantine), the Patuxent Research Refuge, and the Division of Fisheries Research (Leetown, West Virginia), Fish and Wildlife Service to cooperate in studies to determine the effects of these applications on all forms of animal life. This work was continued in 1946 and 1947. The areas studied intensively during these three seasons have varied in size from 100 to 300 acres and the treatments ranged from 1 to 7 pounds of DDT per acre. The study areas often consisted of plots within larger treated areas of over 1000 acres. Entomologists and biologists representing several specialites were assigned to these areas so as to cover fairly well the entire fauna—birds, mammals, cold-blooded vertebrates, and many invertebrates, particularly insects. Terrestrial forms received the most attention in the large plots, and individual applications were made to streams and ponds for the study of aquatic forms. In addition, there was a great deal of laboratory work carried out, particularly on aquatic life. These studies were conducted at or near Beltsville, Maryland, and on treated areas in Pennsylvania, Massachusetts, New York, Virginia, West Virginia, Connecticut, Oregon, Idaho, and Wyoming. Altogether, about 20 different study areas and treatments involving several thousands of acres have been under observation. In addition to these purely experimental plots and special treatments, advantage was taken of several large control projects to examine the general effects of DDT on animals within treated areas such as large blocks of forest treated for the control of the gypsy moth in Pennsylvania, and the 400,000 acres treated for the control of the tussock moth in Idaho in 1947.

In general, it can be said that low dosages—slightly more or less than 1 pound of DDT per acre, which amounts seem to be adequate to control many forest pests—are not measurably destructive to most forest- or stream-inhabiting animals.

All observations seem to indicate that the total insect population is not greatly reduced except for a short time after spray application. It is true that epidemic caterpillars, which were the object of control, some of their parasites, and some of the more succeptible leaf-inhabiting species are practically decimated immediately after spraying except in the "islands" in the forest missed during spraying operations. Most species of insects occur, however, in usual numbers two to three weeks after spraying. The effect on any particular species is conditioned by its susceptibility to DDT, the position it occupies in the treated forest (ground forms are protected by the canopy of leaves), and the stage of development at the time the insecticide is applied.

The effect of widespread insecticidal treatments on parasites has been much discussed. Some interesting observations on a tachinid parasite were obtained this season in connection with the control of the tussock moth on some 14,000 acres on the Umatilla National Forest, Oregon. Practically all of the parasites in flight at the time of the spraying were

killed; however, those that emerged after the spraying was completed plus those that survived in the "islands" missed by the spray were sufficient to parasitize practically all the tussock moth larvae that were not destroyed by disease and those in small areas missed by the spray.

No noticeable effect has been recorded on birds or mammals in any of the areas treated with 1 pound of DDT per acre. It would seem possible that where parent birds are feeding nestlings on caterpillars occurring in epidemic numbers the nestlings might be harmed by the sudden reduction in their food supply or be injured by consuming large numbers of DDT-covered caterpillars. This relationship was studied in 1946 on nestlings in over 50 nests and it was found that artificial feeding with large numbers of DDT-killed budworm larvae followed by a period of partial starvation caused mortality in the nestlings. Thus, it could be possible for such effects to follow control operations. However, no mortality was observed among the nestlings fed naturally by the parent birds in a sprayed area.

Another possible danger to insectiverous birds has been pointed out. The sudden reduction of food for from several days to several weeks, depending on the dosage of DDT, may cause these birds to migrate out of the area. This problem has been studied but no conclusive evidence one way or the other is at hand. One favorable factor is the occurrence of untreated islands in these large-scale operations.

From 1- to 3-mile sections of several streams have been sprayed experimentally by airplane with 1 pound of DDT per acre. Invariably there has been no appreciable damage to fish, turtles, or frogs, but from 70 to 90 per cent mortality of fish food organisms at the lower sampling stations did occur. This upset in the food chain may be considered temporary, however, for a year later the numbers and quantity of bottom insects was about as great as before treatment, but the species composition had changed.

In actual practice there has been little damage to fish and other vertebrates at this dosage. This is probably due to the screening effect of the foliage in the case of the smaller streams and the dilution of the DDT in large volumes of water in the larger streams. When large areas are treated so as to include all the tributaries in a watershed it is conceivable that considerable damage would occur. Actually, on the extensive watersheds treated for gypsy and tussock moths, little damage resulted to aquatic life except in tributaries that were treated 2 or 3 times by mistake.

No appreciable increase in the effects on terrestrial animals was observed where 2 pounds of DDT per acre was used. At 4, 5, and 7 pounds of DDT per acre extensive damage resulted. Drastic reductions in insect populations were recorded shortly after application and prevailed for about 6 weeks. The following year measurable changes in the insect populations were observable in the case of only a few of the several hundred species trapped. The loss of natural enemies caused outbreaks of aphids and mites which were of short duration.

Serious mortality of birds, perhaps 50 to 80 per cent of the populations, occurred immediately following applications of 4 to 7 pounds. Reptiles suffered severely, and practically all aquatic forms of animal life were destroyed. Recovery was delayed and depended to a considerable extent on the size of the area treated.

Preliminary studies in orchard areas, where periodic applications of 5 pounds of DDT per acre are made and where the seasonal totals may approach 50 to 60 pounds of DDT per acre, have indicated that the effects on birds may be disastrous. Heavy kills of birds have also been observed following 4-pound-per-acre dust applications of DDT for tick control.

Laboratory, semi-laboratory, and field experiments all tend to show that DDT suspensions are less damaging to aquatic insects and fish than are oil solutions and emulsions of the poison.

Several of the other new insecticides have been used on a limited scale and some tests run under laboratory conditions, but this work has not progressed sufficiently to draw any conclusions.

In conclusion, we should like to point out that DDT and other new insecticides are powerful tools for the control of insects. The outlook on the use of DDT at the rate of 1 pound per acre for the control of devastating forest pests without causing permanent harm to animal communities is very promising and the effective results obtained in several large control programs mark a new era in the conservation of natural resources. Similarly, the requirements of 0.1 pound of DDT per acre for anopheline larviciding appears to be within the limits safe for desirable aquatic life. The somewhat higher levels required for control of culicine larvae, while marginal, are not likely to cause measurable damage to fish and other valuable aquatic organisms when the work is properly carried on. Nevertheless, many problems exist and it behooves scientists to evolve better formulations and distributing apparatus, to insist upon the correct timing of application, to use minimum dosages to accomplish control, and to make such studies as are necessary to insure that the use of these potent insecticides for the control of pests does not violate established principles of conservation.

The results of the cooperative studies which are very briefly summarized here have been presented in office reports by the agencies concerned or have been published and are available for more detailed scrutiny of those interested.

J. A. BEAL R. D. GLASGOW
H. B. MILLS N. D. WYGANT
F. C. CRAIGHEAD *Chairman*

REPORT OF COMMITTEE ON THE DEVELOPMENT OF MEDICAL ENTOMOLOGY WITHIN THE ASSOCIATION

The Committee appointed by President Cory to study and report on how best to develop medical entomology within the Association has given consideration to the two principal points contained in its instructions, namely:

1. Should a section of medical entomologists be formed within the Association, and
2. "... what action, if any, should be taken to encourage greater consideration of medical entomology in colleges and universities with a view of creating a pool that might function for national security in peace and war."

On the first of these, it is the recommendation of the Committee that a section of medical entomology (which shall include Veterinary Entomology) be formed, and that a committee be appointed to take necessary steps to organize such a section.

The Committee has prepared a petition which has been presented to the Executive Committee. Briefly, the reasons for making this recommendation that

this field receive recognition by the Association are as follows:

1. Scientific discoveries in the control of insects affecting man and other animals are such that this field is developing rapidly. Large sums are being spent on research, and development and on practical control of insects of health importance.
2. A section with regularly scheduled program meetings will provide those members who are engaged in practicing medical entomology with a much needed forum where their mutual problems can be discussed.
3. A review of the papers published in the 1946 volume of the Journal shows that approximately 21 per cent of the total of 250 titles concerned medical and veterinary entomology (of 134 regular papers, 20 per cent; of 116 scientific notes, 22 per cent). The committee hopes that papers of this type will be assembled under an appropriate heading in each issue of the Journal and that the members of the Association will be encouraged to submit their papers on this subject to the Journal for publication.
4. The committee recommends that the chairman of the Section be charged with presenting annually a paper summarizing the principal developments, and particularly advancements, in control procedures for insects affecting man and other animals made during the year. Also, in order that the membership may be kept up-to-date, it is suggested that a current *bibliography* of papers on medical entomology worthy of note appearing in other journals *be regularly published* in the Journal. This should bring the Journal to the fore as a reference work on the subject.

Concerning the second of its assignments, the committee recommends:

1. That a survey be made to determine the present status of the teaching of medical entomology in the universities and colleges of the United States.
2. That from the results of the survey, and in collaboration with officials of those institutions chiefly interested, that a recommended course of study be prepared for the use of college and university authorities in devising their curricula and for the guidance of students intending to specialize in medical entomology.
3. That colleges and universities be encouraged to grant fellowships and scholarships in Medical and Veterinary Entomology.
4. That courses in medical entomology for all students majoring in any field of entomology be required. These required courses to be designed so as to give the student a general orientation in the subject and to be of such a nature that with a minimum amount of additional training he will have a suitable background to handle intelligently the routine control problems which are presented in emergencies.
5. That a standing committee be appointed by the Association to include each year representatives of the Army, Navy, Public Health Service, Bureau of Entomology and Plant Quarantine, the university teaching profession, and of one or more state health departments and other agencies which regularly employ medical and/or veterinary entomologists to develop this field within the Association.
6. That timely articles be published in the Journal encouraging entomologists who served in the armed forces to maintain their inactive reserve commissions, and that the Services be approached on the matter of providing refresher courses in sanitary entomology at intervals for these officers.

F. S. BLANTON — STANLEY F. CARPENTER
A. B. GURNEY — W. W. MIDDLEKAUFF
J. W. ENKE — JOHN D. DECOURSEY
DONALD MCCREARY — GEO. H. BRADLEY, *Chairman*

Chicago Ill.
Dec. 29, 1947

To the Executive Committee
American Association of Economic Entomologists

We the undersigned members of the Association petition for the formation of a Section on Medical Entomology within the Association:
It is further petitioned that the President appoint a provisional chairman and Secretary pending election at the 1948 Annual Meeting.

SIGNED:

R. R. Parker	Wm. P. Hayes
John H. Robinson	Franklin S. Blanton
Horace O. Lund	Charles F. Gerlach
Harry L. Haynes	H. B. Hungerford
Newell E. Good	D. G. Denning
Donald J. Borror	J. W. Enke
Luis F. Martorell	E. R. McGovran
Richard Wm. Fay	Louis J. Milne
William E. Bickley	J. F. Brandenburg
John E. Porter	John H. Hughes
H. S. McConnell	Philip Granett
D. L. Collins	W. E. Dove
E. F. Knipling	G. H. Bradley
Carl P. Mohr	Albert Hartzell
F. C. Bishopp	R. W. Strandtmann
John J. Pratt, Jr.	John D. DeCoursey
Ralph N. Bunn	Roger Smith
Stephen S. Easter	Carroll N. Smith
Ernest N. Cory	G. M. Bentley
Robert Traub	Melvin E. Griffith

REPORT OF THE JOINT COMMITTEE ON THE PREPARATION OF A HISTORY OF ENTOMOLOGY IN RELATION TO WORLD WAR II

DECEMBER 1947

1. The American Association of Economic Entomologists and the Entomological Society of America, at the annual meetings held in Richmond, Va., in December 1946 passed resolutions calling for the appointment of a joint committee on the preparation of a history of entomology in relation to World War II.

2. The committee appointed for this purpose has accomplished the following:

a. Prepared a preliminary outline of the history to serve as a guide in the assembling of information and writing of the report. Copy of this outline is attached. Exhibit A.
b. Prepared and mailed questionnaires regarding war service to entomologists who served in the Armed Forces. Exhibit B. These questionnaires were sent to 415 individuals, and approximately 195 returns were received.

c. Mailed questionnaires to 46 colleges and universities, requesting information concerning entomological contributions to the war effort. Exhibit C. Twelve replies have been received.
d. Secured statements of wartime entomological activities from the Tennessee Valley Authority; U. S. Public Health Service Laboratories at Savannah, Ga., and Memphis, Tenn.; Divisions 9 and 10 of the National Defense Research Committee; the Rockefeller Foundation; and seven divisions of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. In addition, statements from the Malaria Control in War Areas organization and the U. S. Army Typhus Commission have been promised.
e. Requested statements concerning entomological contribution of approximately 20 industrial concerns. Responses were received from eight firms.

3. Much additional work remains to be done in collecting, tabulating and analyzing data; in the assembling of the data obtained; and in writing the manuscript.

4. In view of the above, the following recommendations are made:

a. That Mr. E. C. Cushing be appointed general editor to secure any additional data that are required, analyze the information obtained, and assemble and edit the history. (See Note 1.)
b. That the sponsoring societies authorize the expenditure of $1,000 to pay the editor selected for his time and travel expenses, and to cover clerical assistance required in writing the history.
c. That a joint committee of four be appointed to assist the editor and to serve as an advisory board in the preparation and publication of the history.
d. That the history be printed and issued as a joint publication of the two sponsoring societies following the general format of the Annals of the Entomological Society of America.
e. That cost of publication be met by the two sponsoring societies, utilizing any special funds now available or that may become available for this purpose.

Note 1. Informal inquiry indicates that Mr. Cushing would be willing to assume this repsonsibility under conditions recommended in paragraph 4b. It is believed that his writing ability, familarity with federal and state agencies and industrial concerns, his experience as a commissioned officer during the war and general contacts with the many phases of wartime entomology, qualify him for the task.

Note 2. The American Association of Economic Entomologists mimeographed the questionnaires (2200 sheets) and the Entomological Society of America provided funds to the extent of $21.29 for postage, preparation of correspondence, addressing and mailing of questionnaires. It is believed this is a reasonably equitable division of expenses involved in the activities of the committee.

EDWARD F. KNIPLING RALPH W. BUNN
STANLEY W. BROMLEY PAUL W. OMAN *Chairman*

REPORT OF THE MEMBERSHIP COMMITTEE

The Membership Committee reports that it has considered the applications of 188 persons that were properly certified in due form and accompanied by the required fees. They are accordingly recommended to the Association for election to member ship.

The Committee further reports that the Association has lost from its membership roll during the past year 69 members. Of these, 22 resigned, 12 have died and 35 were dropped for non-payment of dues.

Two members have been recommended for Honorary Membership. The Association has taken action and retained one of these members on the active list with remission of dues and the Executive Committee has acted similarly on the other at this session. Therefore the Membership committee deferred action on these applications.

H. L. SWEETMAN, *Chairman*

LIST OF NEW MEMBERS ELECTED IN 1947

Adler, Howard
Ahmed, Dhia Dean
Ali, Mir Hamed
Allen, Merlin W.
Allison, J. R.
Arey, Philip S.
Arnason, Arni Paul
Ashwander, Ralph E.
Baker, Whiteford L.
Banktson, Edmund W.
Bartholomai, C. W.
Basham, Ernestine H.
Beadle, Leslie D.
Becker, Edward C.
Beckham, Clifford M.
Beutler, Clyde
Bewick, Laurence F.
Black, Clarence
Blalock, John R.
Blickenstaff, Carl C.
Bliss, A. Harry
Branch, Nina C.
Brower, D. G.
Brown, Anthony W. A.
Brown, Winona G.
Buckner, Annette J.
Burnett, Glenn H.
Cabal C., Adriano
Campau, Edward J.
Capelouto, Reuben
Carolin, Valentine M., Jr.
Chamlin, George R.
Choate, M. W.
Christman, Lowell A.
Clark, Edgar W.
Clark, Elton L.
Cline, David L.
Cohill, Roger W.
Colberg, Wayne J.
Cooper, Murray I.
Coulter, William K.
Crooks, Kenneth D.
Curtis, James B., Jr.
Davis, J. M.
Diem, John J.
Dilworth, Hal. C.
Doetschman, Willis Hackett
Dogger, James R.
Donohoe, Eileen L.
Dresher, Paul F.
Dresner, Edgar
Duckworth, L. M.
Earle, Hilton Herman, Jr.
Eden, William G.
Elliott, Marjorie I.
Estabrook, Loren A.
Everly, Ray Thomas
Faulkner, Lloyd R.
Fisher, Theodore W.
Fletcher, Donald G.
Ford, Lloyd W.
Frings, Hubert
Gaines, Ralph C.
Genung, William Gordon
Gibson, Lester H.
Gillogly, Lorin Ray
Goble, H. W.
Griep, Howard Theodore
Griffin, M. Clyde
Hall, David G.
Hamman, Robert Eugene
Hammond, George H.
Hardy, D. Elmo
Harper, Gene M.
Hart, Winfield H.
Hastings, Arthur R.
Heckathorn, Eugene S.
Holdsworth, Robert P., Jr.
Holmes, Edward L.
Hubanks, Paul Edward
Hull, William B.
Hunter, Herman A.
Hutchings, Floyd Wesley
Hutton, George L.
Hyson, Harry C.
Jacobs, Evan Trevor
Jacobson, Martin
Jenkins, Dale W.
Johnson, Ralph J.
Jones, George W.
Kauffman, William
Kindler, James B.
King, John R.
Klock, F. Y.

Knapp, Royce Burton
Kretzschmar, Gerhard P.
Lane, Ira A.
Lauderdale, Robert W.
Lembach, John Vincent
Lieberman, Frank, W.
Lieu, K. O. Victoria
Lin, Sping
Livingston, Arnold Maxwell
Lloyd, Ralph R., Jr.
Lynn, George E.
McCrory, Dean E.
McDonald, Howard
McGregor, S. E.
McKay, Francis
McLeod, James H.
McMahon, Harold Alexander
Maclean, Jeanne Fayette
Magner, J. Marshall
Manzelli, M. A.
March, Ralph Burton
Marucci, Philip Edward
Matsuura, Minoru
Mattis, Arthur J.
Merkel, Edward P.
Messenger, Powers S.
Miller, James F.
Missbach, George E.
Mobley, Lowell
Moore, Herman William
Muiry, James M.
Murphy, Jesse W.
Murphey, Milledge Jr.
Neel, William Wallace
Nikitin, Alexander A.
Nostdahl, Ward D.
Odland, Martin L.
Oman, Paul W.
O'Neal, Edwin J.
Palermo, Michael T.
Parkinson, Kenneth R.
Pela, Albert S.
Perinchief, Morris K., Jr.
Potter, Charles
Probandt, James M.
Quraishi, Mrs. Badarunnisa
Rasmussen, William B.
Reed, John K.
Reeher, Max M.
Roan, Clifford C.
Rockstein, Morris
Roth, Adolph R.
Sager, Wilbert L.
Sampson, W. W.
Saxton, Robert C.
Scales, Arden L.
Schmidt, Carl T.
Schread, John C.
Sessions, A. C.
Shenefelt, Roy D.
Simkover, Harold G.
Smith, Gordon F.
Snow, Donald L.
Somsen, H. Warne
Spurrier, Richard B.
Steffen, A. J.
Steward, Roderick
Stewart, William S.
Stone, Philip V.
Tanada, Yoshinori
Taylor, Earl John
Taylor, Horton G.
Taylor, Lawrence E.
Telford, Paul F.
Thames, Walter Hendrix, Jr.
Thomas, E. Arlo
Thompson, Bayard T.
Thompson, Harvey E.
Tracy, Ralph L.
Tsao, Chi
Uhler, Lowell Dohner
van den Bosch, Robert
Voss, Carroll M.
Wakeman, Robert I.
Walker, George B., Jr.
Warner, Robert M.
Warnhoff, Edward H., Jr.
Warren, James C.
Warren, Lloyd Oliver
Whipp, Arthur Andrew
White, Clarence E.
Wilson Charles S.
Wood, Gilbert Congdon
Wood, Sherwin

REPORT OF THE PUBLICATIONS COMMITTEE

The Publications Committee of the JOURNAL OF ECONOMIC ENTOMOLOGY makes the following recommendations:

1. That the charge for paid publications be increased from $6.00 to $10.00 a page and that payment for publication of articles not be a criterion for acceptance.

2. That the Committee on Common Names be authorized to act upon and approve or reject common names which may be proposed in manuscripts requiring prompt action.

3. That the members of this Association be requested and urged to contribute items of current interest as promptly as possible, and that such items be sent directly to the associate editor.

4. That no one who is not a subscriber to the Journal and a member of the Association be granted the privilege of free publication in the Journal, except that a senior author who fills the above qualifications may include co-authors from allied professions who are not members; also that contributions from non-members who are affiliated with other scientific organizations may be accepted at the discretion of the editor.

F. H. LATHROP
S. E. FLANDERS
W. H. WHITE
T. L. BISSELL
W. E. DOVE
J. A. MUNRO
J. J. DAVIS, *Chairman*

REPORT OF THE CROP PROTECTION INSTITUTE

Throughout 1947 the activities of the Crop Protection Institute continued to occupy various lines of inquiry. The range of investigational work is much greater than it was when the Institute was first organized in 1921. At that time investigations were largely occupied with studies of new stomach poisons or contact insecticides, with improved fungicides, and with certain phases of soil treatments. Today the Institute program still includes the well-known phases of insecticides and fungicides, but it now takes in many lines of inquiry, such as the influences of inert extenders on the performance of dusts, the development of tenacity agents for sprays and dusts, the performance of aerosols, investigations of chemical agents for the control of ticks, exploration of mildewproofing agents, studies of repellents and mothproofers, research in control of weed seeds by chemical agents, the effects of soil applications on the resistance of plants to insects and to fungus or bacterial diseases, and studies in control of internal parasites of animals.

In all of these fields the Institute is performing a large amount of preliminary exploratory work. For that purpose it has developed and is developing new or improved exploratory techniques.

The Board of Governors of the Institute in 1947 included the same personnel as in 1946. The members were as follows: A.M. Boyce, California (Riverside) Experiment Station, D. M. DeLong, Department of Entomology, Ohio State University, and W. C. O'Kane, New Hampshire Experiment Station, Chairman, representing Entomology; H. W. Thurston, Jr., Pennsylvania Experiment Station, Vice-Chairman, J. C. Horsfall, Department Plant Pathology and Botany, Connecticut Experiment Station, and C. R. Orton, Director, West Virginia Experiment Station, representing plant pathology; S. E. A. McCallan, Boyce Thompson Institute, National Research Council; W. H. MacIntire, Tennessee Experiment Station, and H. J. Patterson, Director Emeritus, Maryland Experiment Station, representing chemistry.

Throughout the work of 1947 Dr. M. D. Farrar, Associate Director of the Institute, fulfilled important duties, including the planning of much of the Institute's work and maintenance of various necessary contacts both with experiment station workers and with representatives of a number of industries.

The plan which is followed by the Institute in substantially all of its work involves a close relationship between the Institute's research activities and the laboratories of supporting companies. An important reason for the success of the Institute is to be found in the fact that the research staff of a company maintaining a project with the Institute is kept well advised of the results secured by an Institute worker in his experiments with compounds pro-

vided by a given company. This relationship means that a new product which shows promise is promptly followed up with the aim of improving its performance or discovering some other related product which is still better. The laboratory of the chemical manufacturer is not likely to be in a position to carry on adequate biological investigations nor is the entomologist or plant pathologist in good position to know what new compounds can readily be synthesized. When these two lines of inquiry are brought together progress is sure and more rapid.

Companies supporting research through the Crop Protection Institute in 1947 included the following:

Armour & Company
J. T. Baker Chemical Company
Battelle Memorial Institute
Bridgeport Brass Company
Carbide and Carbon Chemicals Corporation
Davison Chemical Company
Ethyl Corporation
General Chemical Company
Hercules Powder Company
J. N. Huber Corporation
Johns-Manville Corporation
Mallinckrodt Chemical Works
The Mathieson Alkali Works, Inc.
Minnesota Mining and Manufacturing Company
S. B. Penick & Company
Pennsylvania Engineering Company
H. H. Robertson Company
Rohm & Haas Company
Standard Oil Company (Indiana)

Research associates, assistants, and technicians employed by the Institute in 1947 included the following:

William Begany, Ivan C. Brooks, Asher Capelle, Clare Chaplinski, Margaret Chaplinski, Raymond Cowles, Stuart D. Edmond, Thomas Ferraiola, Corinne Flint, Carl F. French, Carter Funnell, Helen Harlan, John B. Harry, Harry L. Haynes, Lawrence J. King, David Laddey, Ted Leverett, John Maps, B. Elwood Montgomery, Wallace J. Morse, Margretta J. Murnan, Winifred Musch, Joseph Pociegiel, Saul Rich, Gloria Shanley, Irene Skok, Howard W. Smith, Ruth Smithers, Robert Zedler.

W. C. O'KANE

Exhibit A

HISTORY OF ENTOMOLOGY IN RELATION TO WORLD WAR II

I. Introduction. Brief history of entomology.
   a. Prior to World War I
   b. During World War I
   c. Between World War I and World War II.
II. Entomological Activity During World War II.
   a. Contributions of entomologists serving with the Armed Forces.
   b. Direct contributions of non-military entomologists to the Armed Forces.
   c. Entomology in relation to national health and economy.
III. Critical Analysis of Entomology in Relation to the War Effort.
   a. Status of entomology at the beginning of World War II
   b. Appraisal of entomological activity during World War II.
IV. Recommendations.

Exhibit B

ENTOMOLOGICAL ACTIVITIES QUESTIONNAIRE ARMED FORCES PERSONNEL

1. Name
2. Service (Army or Navy)
3. Period of service
4. Grade or rank (initial and final)
5. Reserve status
6. Decorations (include citation if possible)
7. If present address is subject to change, give address where you can always be reached
8. List papers published or in process of publication on the work you did during the war
9. Criticisms of the utilization of entomologists during the war, and suggestions for the future
10. Narrative account of war service, including dates, localities, nature of duties, accomplishments, etc. (activities of individual or entomological unit to which assigned)

Send reply to: P. W. Oman, Bureau of Entomology and Plant Quarantine, U. S. National Museum, Washington 25, D. C.

Exhibit C

QUESTIONNAIRE ON ENTOMOLOGICAL CONTRIBUTIONS DURING WORLD WAR II

1. Name of institution or organization.
2. Nature of entomological work having a direct bearing on the protection of military personnel or supplies.
   a. List of projects and nature of work.
   b. Names and titles of personnel assigned.
   c. Duration of project, including dates work was initiated and terminated.
   d. A brief summary of important developments.
   e. List of more important publications or articles in preparation resulting from work at your institution during the war and falling under section 2 of this questionnaire.
3. Nature of entomological activities having a direct bearing on the war effort but not necessarily for the protection of military personnel or supplies. Include such items as training of service personnel, activities of direct importance to the national economy, etc. List major projects, duration, number of personnel assigned, and give a brief summary of developments.
4. Names and present addresses of entomologists with your institution or organization who entered service during the war. (Special questionnaires are being sent to armed forces personnel.)
5. Remarks. Any other pertinent information of possible interest in connection with the preparation of a history of entomology during World War II.

Send reply to: Edward F. Knipling, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Washington 25, D. C.

REPORT OF THE NOMINATING COMMITTEE

The Nominating Committee, consisting of P. D. SANDERS, *Chairman*, A. S. HOYT, and J. G. CONKLIN, submits the following list of nominations for your consideration:

President: S. A. ROHWER
First Vice President: A. M. BOYCE
Secretary-Treasurer: ERNEST N. CORY
Executive Committee: NEALE F. HOWARD (1950)
Committee on Membership
W. B. WOOD (1950)
H. L. SWEETMAN (1950), *Chairman*
Committee on Common Names of Insects
G. J. HAEUSSLER, *Chairman* (1949)
C. F. W. MUESBECK (1950)
E. G. LINSLEY (1950)
Publications Committee
J. J. DAVIS, *Chairman*
F. S. ARANT (1950)
R. W. DEAN (1950)
Program Committee
C. E. PALM, *Chairman* 1948
FLOYD ANDRE (1950)
Committee on Codling Moth
L. F. STEINER, *Chairman* (1950)
J. H. NEWTON (1950)
Committee on Insecticide Terminology
C. H. RICHARDSON, *Chairman* (1948)
J. R. EYER (1949)
H. L. HALLER (1952)
Committee on Cooperation with Pest Control Operators
FRED W. FLETCER, *Chairman* (1948)
L. S. HENDERSON (1950)
Committee on Relation of Entomology to Conservation
H. B. MILLS, *Chairman* (1949)
C. R. TWINN (1950)
FRED WHITEHEAD (1950)
Committee on Grasshopper Research
H. L. SEAMANS, *Chairman* (1948)
H. M. ARMITAGE (1950)
J. A. MUNRO (1950)
Board of Trustees for the Permanent Fund
C. M. PACKARD (1950)
Board of Governors for Crop Protection Institute
A. M. BOYCE (1949)
D. M. DE LONG (1948)
W. C. O'KANE (1950) *Chairman*
Representative on Council of Union of Biological Societies
R. B. FRIEND (1949)
Councilors for the American Association for the Advancement of Science
B. B. PEPPER (1949)
E. R. SASSCER (Alternate)
Editorial Board, Journal of Economic Entomology—
L. M. PEAIRS, *Editor*
H. B. WEISS, *Associate Editor*
ERNEST N. CORY, *Business Manager*

I move the adoption of the above report.

J. G. CONKLIN

REPORT OF THE COUNCILORS FOR THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Your councilors participated in the sessions of the Council of AAAS and of Section F held at Boston in December 1947 and are again in attendance this week at the Council and Section F meetings being held in Chicago.

The recommendations as to the reorganization of Section F are now in full effect. The Executive Committee of that Section, which also constitutes the nominating committee for officers, will hereafter consist of the elected secretaries of nine organizations, including both this Association and the Entomological Society of America.

The most pressing business before the AAAS at the present time is the matter of its financial status in view of its recent purchase of a new site at 16th Street and Massachusetts Avenue, Washington, D. C., and the anticipated necessity of building a new building on that site. The Association has already moved into the buildings already present at that location, but they do not fully meet its needs, and a larger structure will be built in their place as soon as construction is practicable. A building fund for this purpose is being accumulated, and it may be that further contributions from AAS members will be solicited later.

ROGER C. SMITH
S. B. FRACKER
B. B. PEPPER, *Alternate*

REPORT OF THE REPRESENTATIVE TO THE DIVISION OF BIOLOGY AND AGRICULTURE OF THE NATIONAL RESEARCH COUNCIL, 1947

The annual meeting of the Division of Biology and Agriculture, of the National Research Council, held in Washington on April 12, 1947, was attended by Dr. P. N. Annand, United States Bureau of Entomology and Plant Quarantine, who was the representative of this society during the first half of the calendar year just past. An activity of the National Research Council of significance to entomology and which was reviewed at that meeting, is the work of the Chemical-Biological Coordination Center, an outgrowth of the Insect Control Committee. The program of the Center has been discussed in some detail by Dr. R. B. Friend at the present meeting of this Association. A number of entomologists are amongst the workers from the several fields of biological effort in universities and governmental agencies who are collaborating with the Center in this project. In its essentials this work involves the collection and correlation of data as to chemical properties and the biological effects of complex compounds, organic and inorganic. Correlations will require the mechanical sorting of punch cards bearing coded data. The development of a satisfactory code has alone presented major problems. To speed the accumulation of new information for this program, the preliminary screening of compounds is being sponsored by the Center. Screening programs for insecticidal and insect repellent actions are underway.

Nine delegates from the National Research Council attended the IXth General Assembly of the International Union of Biological Sciences held in Copenhagen, July, 28, 1947, the first such meeting since 1935. Representatives of UNESCO and of the International Council of Scientific Unions met with delegates from 16 countries. Dr. Stuart Mudd of the University of Pennsylvania, one of the delegates of the National Research Council, was made associate secretary-general of the IUBS. The meeting of the latter organization is of particular interest in that the plans for setting up several new sections of the Union include one for entomology.

In order to serve the common interests of biologists through cooperative action an American Institute of Biological Sciences is being organized by a board convened by the National Research Council.

A report on this activity will be made by Dr. S. B. Fracker who represents this society on the Organizing Board.

Respectfully submitted
HAROLD H. SHEPARD

REPORT OF MEETING OF THE SECTION OF APICULTURE

The Section of Apiculture of the American Association of Economic Entomologists opened at 2 P.M. December 28, 1947, in Parlor D of the Congress Hotel with Dr. W. C. Roberts of Madison, Wisconsin, presiding as Acting Chairman. V. G. Milum of Urbana, Illinois, served as Acting Secretary.

The following papers listed on the printed program were presented by their respective authors with the exception of No. 2 which was read by Dr. Montgomery: 1, 2, 3, 4, and 8.

1. Serological Evidence of Resistance in Larvae and Workers to Bacillus Larvae. N. D. Gary, C. I. Nelson and J. A. Munro, Fargo, N. D.

2. Some Factors Affecting the Color of Honey. V. G. Milum, Urbana, Illinois.

3. Studies on the Sugar Content of Floral Nectars. O. W. Park, Ames, Iowa.

4. Causes of Deficiency of Soy Bean Flour as Pollen Substitute for Honeybees. M. H. Haydak, St. Paul, Minnesota.

8. Further Sulfathiazole Developments. Leonard Haseman, Columbia, Missouri.

In addition, Dr. S. E. McGregor of the U. S. Bee Culture Laboratory at Madison, Wisconsin discussed briefly the results recorded in Bulletin 207 of the Arizona Agricultural Experiment Station entitled, "Beekeeping Near Cotton Fields Dusted with DDT." Some results of genetical studies with honeybees were presented by Dr. W. C. Roberts of Madison.

A nominating committee appointed by the acting chairman, consisting of F. E. Todd, O. W. Park and F. E. Guyton placed in nomination the names of E. J. Dyce of Cornell University as Chairman for 1948 and W. A. Price of Lexington, Kentucky as Secretary, who were unanimously elected.

V. G. MILUM
Acting Secretary

REPORT OF THE MEETING OF THE SECTION OF PLANT PEST CONTROL AND QUARANTINE

The meeting of the Section on Plant Pest Control and Quarantine, of the American Association of Economic Entomologists, was held at the Congress Hotel in Chicago on Sunday afternoon, December 28, 1947. The meeting was called to order at 1:45 by Chairman Roy S. Richmond.

The chairman made several general announcements and appointed a nominating committee consisting of Dr. E. R. Sasscer and Mr. E. L. Chambers, after which he opened the program with a very interesting address on "Soil As a Carrier of Agricultural Pests."

The following program was then presented:

1. What steps, short of exclusion of host material can be taken to prevent foreign plant viruses becoming established in the United States. E. C. Stakman, St. Paul, Minn.

2. (a) What practical means are available to eliminate virus disease from plants offered for entry into the United States:

(b) What practical treatments are available to eliminate virus disease from plants offered for import. C. R. Orton, Morgantown, W. Va.

3. Regulatory considerations for exclusion of foreign plant viruses. Clay Lyle, State College, Miss., and C. A. Boyer, Lansing, Michigan.

3. Regulatory considerations for exclusion of foreign plant viruses. Clay Lyle, State College, Miss., and C. A. Boyer, Lansing, Michigan.

Following the presentation of these topics there was a lively and interesting discussion of some of the thoughts projected, in which many of those present participated. Of special note was the interest shown toward setting up detention stations in the United States for growing certain imported plants under proper supervision and observation for a sufficient time to establish whether or not they are diseased.

The nominating committee submitted the following names for office for 1948:

C. R. WILLEY, *Chairman*
H. S. DEAN, *Secretary*

The nominations were accepted and the nominees elected.

C. R. WILLEY, *Secretary*

REPORT OF SECTION OF EXTENSION

The section of Extension Entomologists met at 7:30 P.M., December 27, 1947 in parlors A and B of the Congress Hotel, Chicago, Illinois. In the absence of Mr. W. C. Nettles, Chairman, Mr. C. F. Stiles acted as chairman as well as secretary. Extension Entomologists were present from 16 states and all took part in the discussions. There were 50 in attendance which included members of the Bureau of Entomology and Plant Quarantine, state workers and commercial men.

The theme of the meeting was Problems, Policies and Programs of the Extension Entomologists. Mr. G. E. Lehker of Indiana and Mr. H. B. Petty of Illinois discussed the Garden and Truck Crop Insect Problems and recommended that the control recommendations be as simple as possible for the home gardener and that the insecticide dealers know in advance what your recommendations for the coming year will be so that they can have materials on hand when needed.

Insects Affecting Man and Domestic Animals was ably discussed by Mr. George D. Jones of Missouri, Dr. Martin Muma of Nebraska and Mr. Stirling Kyd of Oklahoma. Mr. Jones' talk was along the lines of the rural health program in the states and what the Extension Entomologists could do to further this program. The remarks of Dr. Muma and Mr. Kyd were mainly in regard to formulations and dosages of the new insecticides for the control of animal parasites. Grain Conservation Through Insect Control was discussed by Mr. T. H. Parks of Ohio and others. It was pointed out that by controlling insects in stored grain that large savings would result and much more grain would be available for export to foreign countries.

Mr. E. H. Fisher of Wisconsin discussed the European Corn Borer Control in Wisconsin and favored well planned meetings for presenting the latest control methods to farmers.

Dr. Ray L. Janes of Michigan discussed The Functions of the Michigan Insecticide and Fungicide Institute and how it had helped him in his work.

The Uses of the New Organic Insecticides were

discussed by Dr. J. N. Roney of Arizona and a general discussion followed. He brought out the fact that due to the differences in climatic conditions formulations in one part of the country might not be adapted to conditions in other parts.

Mr. G. E. Lehker of Indiana was elected chairman and Mr. J. O. Rowell of Virginia was elected secretary for the coming year.

C. F. STILES, *Secretary*

PROCEEDINGS OF THE TWENTY-FIRST ANNUAL MEETING

COTTON STATES BRANCH

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The twenty-first annual meeting of The Cotton States Branch of The American Association of Economic Entomologists was held in Biloxi, Mississippi, on January 14, 15, 16, 1947. These meetings were held in conjunction with the annual meeting of The Association of Southern Agricultural Workers. Approximately two hundred persons attended the sessions, including representatives from all eleven states constituting the Cotton States Branch territory, as well as representatives from Canada, and eastern, midwestern, and Pacific Coast areas of the United States. Interest was maintained at a high level during all sessions.

Chairman R. C. Gaines called upon his storehouse of knowledge pertaining to cotton insects in presenting the chairman's address. The Branch membership was honored by the presence of Doctor Ernest N. Cory, President of The American Association of Economic Entomologists; Doctor Z. P. Metcalf, President of The Entomological Society of America, and Past Chairman of the Cotton States Branch; and Doctor Arthur Gibson, Past President of The American Association of Economic Entomologists, and past chief of the Division of Entomology of Canada. These three prominent entomologists gave excellent addresses during the course of the meetings.

The number of active members in the Cotton States Branch on January 1, 1947 was 367. There are fifty contributing members, making a grand total of 417.

During the year 1946–47 the Branch received funds totaling $530.60 and expended a total of $244.37. The balance on hand January 10, 1947 was $286.23.

Officers elected for the year 1947–48 were as follows: Dwight Isely, Chairman, University of Arkansas; Floyd F. Bondy, Vice-Chairman, Bureau of Entomology and Plant Quarantine; Z. P. Metcalf, Member of the Committee on Popular Entomological Education, North Carolina State College; and John T. Creighton, *Entoma* Representative, University of Florida. The term of office of the Secretary-Treasurer does not expire until the annual meeting in 1947.

JOHN T. CREIGHTON, *Secretary-Treasurer*

MEETINGS OF OTHER ENTOMOLOGICAL GROUPS

TWENTY-SECOND ANNUAL MEETING ENTOMOLOGICAL SOCIETY OF PENNSYLVANIA

The twenty-second annual meeting of the Entomological Society of Pennsylvania was held in Room 107 South Office Building, Harrisburg, Pennsylvania on January 15, 1948 at 4 P.M.

Those in attendance were Harold Steiner, Flora Dale, Pa.; E. J. Udine, State College, Pa.; George B. Sleesman, Norristown, Pa.; J. O. Pepper, State College, Pa.; H. W. Frings, State College, Pa. H. Menusan, Jr., State College, Pa.; S. W. Frost, State College, Pa.; S. G. Gesell, State College, Pa.; T. L. Guyton, Harrisburg, Pa.; C. A. Kent, Harrisburg, Pa.; A. B. Champlain, Harrisburg, Pa.; E. M. Craighead, Harrisburg, Pa.; W. Wheatfield, Harrisburg, Pa.; C. F. Campbell, Wilkes-Barre, Pa.; H. A. Strohecker, Norristown, Pa.

The meeting was called to order by Dr. Steiner and the minutes were read by E. J. Udine, Secretary. The following officers were elected for 1948: GEORGE B. SLEESMAN, *Chairman*, DR. M. W. EDDY, *Vice Chairman*, E. J. UDINE, *Secretary*.

Dr. H. W. Frings gave an illustrated talk on ultrasonics in which he discussed its basic principles and its effect on insects and animals. He also discussed its advantages and disadvantages and its possible use for insect and rodent control as well as a possible repelling agency.

Following Dr. Frings' talk the members entered into a round table discussion of insect problems and entomological work done in Pennsylvania.

Dr. Menusan, Mr. Gesell and Mr. Udine discussed conditions in the field during the past year emphasizing an increase in mites and aphids. Mr. Pepper suggested that members watch for tomato russet mite and to take a conservative view on new insecticides until further research warrants their use. Mr. Campbell reported on Gypsy moth progress and plans for the coming year. Dr. Frost discussed the progress of an ecological survey conducted by The Pennsylvania State College. Dr. Frost also gave interesting facts on inaudible sounds relative to insects.

Dr. Guyton reported finding a curculio, *Apion longirostre* Oliv., new to Pennsylvania attacking hollyhocks in the northwestern part of the State.

Mr. Craighead reported on nursery inspection. He also reported that no infestation of the potato rot nematode had been found in the state.

Dr. Steiner gave the results of commercial scale experiments with new insecticides in orchards. Mr. Sleesman suggested that the members send him scale insects for identification and distribution records.

Geo. B. Stichter was appointed Chairman of a Committee to prepare a history of the society to be given at its 25th annual meeting.

The meeting adjourned at 6:45 P.M.

E. J. UDINE, *Secretary*

THE NEWELL ENTOMOLOGICAL SOCIETY

The Society, having been inactive during the war years, resumed its activities on October 31, 1946, at which time ten new members were initiated, and Mr. William B. Gresham was elected to serve as the new

president. The society, which has the distinction of being the only student organization in the United States that is an affiliate of the American Association of Economic Entomologists, then began an active and successful year. Subsequent meetings featured guest speakers, entertainment of guests, and refreshments. Guest talks included an illustrated talk with excellent color slides of varieties of camellias developed by Dr. Hume and others, given by Dr. Harold Hume on the plant history and development of camellias. Dr. Hume is a prominent authority on camellias. Dr. L. E. Swanson, parasitologist at the Florida Experiment Station, gave a movie-illustrated account of experiences relating to entomology during an expedition to Costa Rica and Central America. He gave interesting observations on fly larvae found in the skins and digestive tracts of cattle, deer, birds, dogs, and humans. Dr. John T. Creighton, faculty sponsor and advisor of the society and head of the Department of Entomology, gave a talk on the history and aims of the society, and the purposes of the annual conference.

The Newell Entomological Society sponsored the Eighth Annual Florida Entomological Conference on May 8, 9, 1947. The conference was the first held since May 1, 1942, suspension of activities being due to the war. The 1947 conference was held at the Department of Entomology of The University of Florida, College of Agriculture. The conference opened with a picnic dinner for visiting entomologists and friends. During the evening new members were initiated and honorary members inducted. Mr. Charles L. Remington acted as the genial Master of Ceremonies for this occasion.

On Friday morning special memorial exercises were held for Doctor Wilmon Newell, for whom the society is named; J. Lacy Barton, and H. N. Kluepelberg, two members who gave their lives in the service of their Nation. Doctor John T. Creighton, Head of the Department of Entomology, and Mr. William B. Gresham, President of The Newell Entomological Society, presided. Professor Andrew J. Rogers paid tribute to Doctor Newell, while tributes to Barton and Kluepelberg were rendered by Paul J. Hunt, and William B. Gresham. Daniel U. Duncan, a member of the society, sang "Goin' Home," from the Largo of The New World Symphony.

The paper reading sessions included the following:

Report of Entomological work on Leyte in the Philippine Islands. JAMES H. HEIDT, Graduate Student, Department of Entomology, University of Florida, Gainesville.

Current Uses of Hexachlorocyclohexane and Hexaethyl Tetrophosphate in Florida. JAMES TOFFALETI, Entomologist, California Spray Chemical Company, Orlando, Florida.

Report of Entomological work at Dakar in French West Africa. T. ROY YOUNG, Young and Jones Laboratories, Tampa, Florida.

The Nature of Mosquito Control Work Being Done in Palm Beach County. EDWIN L. SEABROOK, Director, Palm Beach County Anti-Mosquito District, West Palm Beach, Fla.

Entomological Observations in Northern Africa and Europe. WILLIAM GENUNG, Student, Department of Entomology, University of Florida, Gainesville.

Report of Entomological Work on Guadalcanal in Solomon Islands, and Okinawa in Japanese Islands. ANDREW J. ROGERS, Professor of Entomology, University of Florida, Gainesville.

Report of Entomological Activities on Guam in the Marianas Islands, and Shantung Province of North China. JOHN FREDERICK, Florida East Coast Fertilizer Company, Homestead, Florida.

The Past and Future Outlook of Entomology in the Florida State Board of Health. JOHN A. MULRENNAN, Director, Division of Entomology, Florida State Board of Health, Jacksonville, Florida.

Navy Entomologists in the Pacific. W. S. FLETCHER, Arcadia, Florida.

Comparative Effectiveness of DDT in Lime and Other Diluents. Illustrated. LAWRENCE A. HETRICK, JR., Professor of Entomology, University of Florida, Gainesville, Florida.

Report of Entomological Activities in New Guinea. LEWIS S. MAXWELL, Entomologist, Swift and Company, Winter Haven, Florida.

Malaria Control Experiments of the United States Public Health Service. JOHN H. RUSSELL, Entomologist, Pennsylvania Salt Manufacturing Company, Sanford, Florida.

The conference was terminated by the annual banquet. The 1947 banqet was given in honor of graduates and former members who rendered noteworthy service to the nation on battlefronts and the homefront. Doctor H. HAROLD HUME, Provost for Florida Agriculture, was the principal speaker.

During the summer of 1947 the society became inactive, but resumed its activities at the beginning of the fall semester. Mr. WALTER H. THAMES, JR., was elected the new president. An interesting addition to the proceedings of the meetings was introduced by Professor L. A. Hetrick—a period during which members of the society present brief notes and display specimens of unusual interest.

A special project to increase the funds of the society was undertaken. The society approved advancement of examination and certification fees to members who will be examined and certified as licensed pest control operators by the Florida Structural Pest Control Board. These members will conduct F.H.A. termite inspections. In addition to providing additional funds for the treasury of the society, the work is providing valuable experience for those members conducting these inspections. On the lighter side, a fish fry was held in the beautiful College of Agriculture Park. Plenty of black bass were provided by student members. At a later social function, initiation of ten new members was carried out in the traditional vein of humor. Those now serving as society officers are Walter H. Thames, Jr., President; Charles Remington, Vice-President; Howard V. Weems, Jr., Secretary; Paul Hunt, Jr., Treasurer; and George Walker, Reporter.

HOWARD V. WEEMS, JR., *Secretary*

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FOREIGN MEMBERS

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LIST OF MEMBERS DECEASED IN 1947

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